PB85-173839

Ozone Production and Transport in the Atlanta, Georgia Region

Washington State Univ., Pullman

Prepared for

Environmental Protection Agency
Research Triangle Park, NC

Feb 85

U.S. Department of Commerce
National Technical Information Service
NTIS

PB85-173839

EPA/600/3-85/013
February 1985

OZONE PRODUCTION AND TRANSPORT IN THE ATLANTA, GEORGIA REGION

BY

Hal Westberg and Brian Lamb
Laboratory for Atmospheric Research
Washington State University
Pullman, Washington 99164-2730

Grant No. CR 809221

Project Officer

William Lonneman
Atmospheric Chemistry and Physics Division
Atmospheric Sciences Research Laboratory
Research Triangle Park, North Carolina 27711

ATMOSPHERIC SCIENCES RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA/600/3-85/013	**2.**	**3. RECIPIENT'S ACCESSION NO.** PB85 173839/AS
4. TITLE AND SUBTITLE OZONE PRODUCTION AND TRANSPORT IN THE ATLANTA, GEORGIA REGION		**5. REPORT DATE** February 1985
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Hal Westberg and Brian Lamb		**8. PERFORMING ORGANIZATION REPORT NO.**
9. PERFORMING ORGANIZATION NAME AND ADDRESS Laboratory for Atmospheric Research Washington State University Pullman, Washington 99164-2730		**10. PROGRAM ELEMENT NO.** CDWA1A:01 0315 (FY-85)
		11. CONTRACT/GRANT NO. CR 809221
12. SPONSORING AGENCY NAME AND ADDRESS Atmospheric Sciences Research Laboratory-RTP, NC Office of Research and Development U.S. Environmental Protection Agency Research Triangle Park, North Carolina 27711		**13. TYPE OF REPORT AND PERIOD COVERED** Final
		14. SPONSORING AGENCY CODE EPA/600/09

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The report presents the results from air quality monitoring program conducted in the Atlanta, Georgia region during July 1981. The study included data collected at several ground sites as well as airborne measurements using an instrumented aircraft. Study participants included Washington State University and Gas Kinetics and Photochemistry Branch, U.S. Environmental Protection Agency, Research Triangle Park, NC. Measurements included ozone, oxides of nitrogen, PAN, individual hydrocarbons (C_1 - C_{10}), halocarbons, condensation nuclei, visual distance plus numerous other meteorological parameters. Isoprene and monoterpene emission rates were determined for the most abundant vegetation species in the Altanta region. Three SF_6 tracer release experiments were performed in order to better understand dispersion patterns in the Atlanta area. Some study observations include: (1) The observed 6-9 AM HC/NO_x ratio in Atlanta was 8.6 compared to the value of 1.5 estimated from emission inventories, (2) the natural hydrocarbon burden to the total nonmethane concentration ranged from 2 to 7%, and (3) ozone predicted by a city specific EKMA treatment agreed well with observed O_3 concentrations.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	**19. SECURITY CLASS** *(This Report)* UNCLASSIFIED	**21. NO. OF PAGES** 244
	20. SECURITY CLASS *(This page)* UNCLASSIFIED	**22. PRICE**

NOTICE

The information in this document has been funded by the United States Environmental Protection Agency under Grant No. CR-809221 to Washington State University. It has been subject to the Agency's peer and administrative review, and it has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

ABSTRACT

An air quality monitoring program was conducted in the Atlanta region during July, 1981. This field study included data collection at several ground stations as well as airborne measurements using an instrumented aircraft. Measurements included ozone, oxides of nitrogen, PAN, individual hydrocarbons (C_2-C_{10}), halocarbons, condensation nuclei, and visual distance plus numerous meteorological parameters. Isoprene and monoterpene emission rates were determined for the most abundant natural vegetation species in the Atlanta region. Three tracer (SF_6) experiments were performed in order to better understand dispersion patterns in the Atlanta area. Specific objectives of this research were 1) to quantify oxidant transport and production in the Atlanta plume; 2) to characterize anthropogenic and biogenic ambient hydrocarbon concentrations; and 3) to determine the contribution of natural hydrocarbon emissions to oxidant production in the Atlanta area.

A well-defined pollutant plume was observed downwind of Atlanta on most afternoons during the study period. Ozone levels in the 130-160 ppb range were commonly observed at distances of 35-45 miles from the urban core. Elevated b_{scat} values were also observed in the Atlanta plume. Nonmethane hydrocarbon concentrations ranging from 113 to 1677 ppbC were recorded at Atlanta sampling sites during the 6-9 a.m. time period. A mean concentration of 491 ppbC was calculated from about 50 samples. Mean NO_x concentrations varied from 44 to 68 ppb at three urban monitoring sites. A mean HC/NO_x ratio of 8.6 was observed during the 6-9 a.m. period in Atlanta. Biogenic hydrocarbons

including isoprene, α-pinene, β-pinene, Δ^3-carene and myrcene were routinely detected in air samples collected during the 6-9 a.m. period. The natural hydrocarbon burden in these samples varied from 2 to 7% at four sampling sites in the Atlanta area.

Ozone concentrations predicted by city specific EKMA (OZIPP) agreed reasonably well with observed concentrations. This modelling effort consisted of assigning measured precursor and meteorological parameters to the 8 a.m. Atlanta air parcel, documenting the air parcel trajectory, and comparing ozone concentrations measured in the air parcel later in the day with model predictions. The OZIPP ozone concentrations were generally about 10% below the observed levels.

The trajectory analysis used to assign locations to the predicted maximum ozone concentrations was tested against the results of the SF_6 tracer experiments. At distances out to 45 miles, the calculated trajectories and the paths of the tracer plume were in good agreement.

An analysis of a recent hydrocarbon and NO_x anthropogenic emissions inventory for the Atlanta area indicated that the HC/NO_x ratio calculated from the emissions data was 1.5 while the mean ratio observed in ambient samples was 8.6. Application of a simple box model using the emissions data yielded good agreement between predicted and observed NO_x concentrations, but the predicted anthropogenic hydrocarbon concentration (99 ppbC) was approximately five times less than the mean observed concentration (491 ppbC). These results suggest that the anthropogenic hydrocarbon emission inventory may be severely underestimated.

An emission inventory of biogenic hydrocarbons developed from a series of vegetation enclosure samples collected during the study yielded area wide

average fluxes of 2500 μg/m^2·hr for isoprene and 90 μg/m^2·hr for alpha-pinene. These levels are similar to those reported for other areas in the U.S. Application of the box model using these rates provided an upper bound on the observed biogenic hydrocarbon concentrations. On a 3.2 km x 3.2 km (2 x 2 mi) grid average basis, the maximum gridded anthropogenic hydrocarbon flux was 26,600 μg/m^2·hr. The 97 km x 97 km (60 x 60 mi) area average emission flux of anthropogenic hydrocarbons was 1350 μg/m^2·hr.

CONTENTS

Abstract iii
Figures viii
Tables x
Acknowledgment xii

1. Introduction 1
2. Summary and Conclusions 3
3. Experimental Procedures 8
4. Results and Discussion 10
    Meteorology 10
    Ozone Precursor Emissions 12
    Oxidants. 27
    Oxidant Production and Transport. 33
    EKMA Modeling 55
    Emission Inventories. 62

References 85

Appendices

A. Quality Assurance Document. 87
B. Hourly Average Air Quality and Meteorological Data. . . 141
C. Upper Level Winds Measured at DeKalb-Peachtree Airport. 165
D. Meteorlogical Data Collected at Georgia Tech (Data Provided by Georgia Tech University, School of Geophysical Sciences). 194
E. Aircraft Flight Maps. 209

FIGURES

Number Page

1 Location of ground level sampling sites in Atlanta. 9

2 Map showing location of high pressure system over the Gulf of Mexico 11

3 Daily maximum ozone trends at the DeKalb-Peachtree, Georgia Tech, DeKalb CC and Conyers sites 29

4 Mean daily maximum ozone concentration for the combined four station network (DeKalb-Peachtree, Georgia Tech, DeKalb CC and Conyers) 31

5 Maximum hourly average PAN and O_3 concentrations recorded at the Georgia Tech site 34

6 July 17, 1981, morning (8:05-10:18 a.m.) flight path with ozone concentrations (ppb) marked along the route. Altitude of the flight ranged between 1500 - 2500 ft.. 37

7 Ozone and b_{scat} measured with the aircraft southeast of Atlanta during the morning hours on July 17, 1981. 38

8 Ozone and temperature changes with altitude recorded at 8:15 a.m. on July 17, 1981. 40

9 July 17 afternoon (12:42 - 15:48 p.m.) flight path with ozone concentrations (ppb) marked along the route 42

10 Ozone and temperature changes with altitude recorded at 1:00 p.m. on July 17, 1981. 43

11 Aircraft traverses across the Atlanta plume on the afternoon of July 17, 1981 44

12 Crosswind ozone profiles recorded in the Atlanta plume at 2500 feet on July 17 45

13 Ozone and temperature changes with altitude recorded at 8:30 a.m. on July 24, 1981. 49

14 Ozone and temperature changes with altitude recorded at 1:00 p.m. on July 24, 1981. 51

Figures cont'd.

Number Page

15 Pollutant changes at the Georgia Tech site on July 24, 1981 . . . 54

16 Predicted air mass trajectory in relation to aircraft traverses of Atlanta plume during the afternoon hours of July 17, 1981. . . 60

17 Isoprene flux versus ambient and enclosure temperature for deciduous species in Atlanta and from enclosure and micrometeorological gradient data collected in a mixed deciduous forest in Pennsylvania. The biomass factor used was 379 g/m^2. . 67

18 Isopleths of SF_6 tracer concentrations observed at hourly-averaged sample points and along automobile sampling traverses during Test 1. 73

19 Isopleths of SF_6 tracer concentrations observed at hourly-averaged sample points and along automobile sampling traverses during Test 2. 75

20 Isopleths of SF_6 tracer concentrations observed at hourly-averaged sample points and along automobile sampling traverses during Test 3. 78

21 Crosswind concentration profiles at SF_6 obtained with a continuous SF_6 analyzer during automobile traverses along I-285 8 miles downwind of the source. Crosswind distances are in reference to the I-20 - I-285 junction. 79

22 Average crosswind SF_6 concentration profiles and best-fit Gaussian curves along I-285 8 miles downwind of the source. Crosswind distances are in reference to the I-20 - I-285 junction 80

23 Forward air parcel trajectories for various starting times during Test 1, 2 and 3 82

TABLES

Number Page

1 Individual Hydrocarbon Concentrations Measured Between 7:30 - 9:00 a.m. at the DeKalb-Peachtree site on July 17, 1981 . . . 14

2 0600-0900 Nonmethane Hydrocarbon Concentrations (ppbC) Obtained by Summing the Individual Species 15

3 Mean Nonmethane Hydrocarbon Concentrations (ppbC) Measured Between 6-9 a.m. in Eight Urban Areas 16

4 Percentage Distribution of Hydrocarbons by Class in Samples Collected at Atlanta Sites During the 6-9 a.m. Period. 16

5 Average Concentration (ppbC) of Selected Hydrocarbons at DeKalb-Peachtree (0600-0900) 17

6 Average Concentration (ppbC) of Selected Hydrocarbons at Fulton County (0600-0900). 19

7 Average Concentration (ppbC) of Selected Hydrocarbons at Georgia Tech (0600-0900) 21

8 Average Concentration (ppbC) of Selected Hydrocarbons at DeKalb CC (0600-0900). 23

9 NO_x Concentrations (ppb) Measured at Atlanta Area Sites Between 6-9 a.m 26

10 Daily Maximum Ozone Concentration (ppb-hourly average) Recorded at Surface Sites in the Atlanta Area During the Study Period 28

11 PAN Hourly Average Concentrations (ppb) at the Georgia Tech Site During the Period July 11 - Aug. 3, 1981 32

12 Meterorological Data Recorded on July 17, 1981 36

13 Hourly Average Surface Ozone Concentrations (ppb) on July 17. 39

14 Meteorological Data Recorded on July 24, 1981 48

15 Hourly Average Surface Ozone Concentrations (ppb) on July 24. 52

TABLES cont'd.

Number Page

16 Hydrocarbon Data Collected at the Georgia Tech Site on July 24, 1981. . 53

17 Morning and Afternoon Hydrocarbon Species Distributions in Atlanta on July 24, 1981 55

18 Summary of OZIPP Modeling Results 58

19 Annual Emission Rates of NO_x and NMHC from Point and Area Sources . . . 62

20 Area Source Emission Rate Data for Nonmethane Hydrocarbons. 63

21 Biogenic Hydrocarbon Emission Rates, Atlanta, 1981. 66

22 Estimated Isoprene and Alpha-Pinene Emission Rates. 69

23 Tracer Release and Surface Meteorological Data. 72

24 Hourly-Averaged Tracer Data, Test 1 74

25 Hourly-Averaged Tracer Data, Test 2 76

26 Hourly-Averaged Tracer Data, Test 3 77

ACKNOWLEDGMENTS

The authors wish to thank the Environmental Protection Agency for financial support of this work. The guidance and technical advice provided by Bill Lonneman was much appreciated. The assistance provided by EPA Region IV, the State of Georgia and Georgia Tech is greatfully acknowledged.

Members of the Washington State University staff that contributed to this program include: Chris Buri, Darren Hall, Bob Koppe, Don Stearns, Tom Twilligear and Ralph Vin Camp.

SECTION 1

INTRODUCTION

It has become apparent in recent years that photochemical smog problems exist in many sections of the United States. Ambient ozone concentrations commonly exceed the National Ambient Air Quality Standard around the major urban centers in California, Texas, and throughout much of the midwestern and eastern United States. Oxidant levels in excess of the standard are recorded in rural as well as urban regions of the country. Many studies have been undertaken to determine the source(s) of the high ozone concentrations in these urban and rural areas. The production of oxidants in urban plumes and subsequent transport into rural regions is now well documented. However, considerable controversy still exists regarding photochemical ozone production from naturally emitted hydrocarbons. In many cases, natural hydrocarbon emission estimates appear to be comparable to anthropogenic hydrocarbon emission inventories. However, the direct comparison of natural and anthropogenic emission inventories is probably not a valid method for apportioning ozone contributions. Uncertainties in anthropogenic hydrocarbon emission inventories and in the fate of naturally emitted organics make it difficult to predict the impact that each of these categories will have upon the development of oxidants in a particular region.

In order to improve our knowledge of the factors governing oxidant production and transport in different regions of the United States, a comprehensive air quality monitoring program was conducted in the Southeast during the summer of 1981. The Atlanta, GA area was selected for study because it provided a large, isolated city surrounded by natural vegetation. Specific goals of the research program included: 1) measurement of anthropogenic ozone precursor concentrations in Atlanta, 2) development of a natural hydrocarbon emissions inventory for a 100 by 100 km area around Atlanta, 3) documentation of ozone production in and around Atlanta, and 4) acquisition of a meteorological data base sufficient for air quality modeling. All of these objectives were achieved, although the data base is somewhat limited in that the field study spanned only three weeks. Air quality data were collected between July 13 and August 3, 1981. The purpose of this report is to provide a tabulation and discussion of the data collected during the study period.

SECTION 2

SUMMARY AND CONCLUSIONS

Specific components of the intensive monitoring program conducted in Atlanta during July, 1981, included measurement of ozone precursor concentrations in Atlanta, chemical characterization of the upwind air flow, and monitoring of oxidant production and transport downwind of Atlanta. The results of this sampling effort were used for evaluation of the city specific EKMA model (OZIPP). Trajectories calculated from wind observations during the study were used to locate predicted maximum concentrations, and several SF_6 urban tracer releases were performed to aid in the analysis of pollutant transport originating in Atlanta. This work also included the documentation of available anthropogenic hydrocarbon and nitrogen oxides emission inventories and estimation of a similar biogenic hydrocarbon emission inventory based upon a series of vegetation enclosure samples collected during the field study. The various tasks directly related to investigation of ozone formation were accomplished through the operation of an instrumented aircraft during 14 days along with the use of two special field monitoring laboratories and several existing air quality monitoring sites during a total of 22 sampling days.

OXIDANT PRECURSORS

Early morning (6-9 a.m.) total nonmethane hydrocarbon concentrations were obtained from gas chromatographic analyses of individual species. The average concentrations varied between 113 and 1677 ppbC with a mean equal to 491 ppbC at four urban/suburban sites. These values are somewhat low compared to similar measurements from a number of other U.S. cities. The mean distribution of hydrocarbons was approximately 55% paraffin, 15% olefin, and 30% aromatic, but this distribution varied widely from day to day.

Biogenic hydrocarbons were routinely detected in the early morning samples at the DeKalb CC site and on most days at Georgia Tech and DeKalb-Peachtree. These included isoprene, alpha-pinene, beta-pinene, Δ^3-carene, and myrcene. The total biogenic contribution to ambient NMHC varied from 2% to 7%. Isoprene typically constituted 1% of the total NMHC.

Average concentrations of nitrogen oxides measured during the 6-9 a.m. period ranged from 10 to 200 ppb, and the mean NO_x concentrations measured at four sites were between 44 and 68 ppb. Mean HC/NO_x ratios at these sites were similar with a mean of 8.6 which is quite comparable to ratios observed in other urban areas.

OXIDANT PRODUCTION AND TRANSPORT

The NAAQS for ozone of 120 ppb was exceeded on 3 different days at a site 24 miles downwind of urban Atlanta, and the standard was exceeded at urban sites during one of those days. The maximum hourly average ozone concentration was 172 ppb observed in the urban center. Daily maximum hourly averaged ozone concentrations were less than 60 ppb on seven days, in the range 80-110 ppb on fourteen days, and greater than 150 ppb on one day. Maximum hourly average concentrations of PAN closely tracked the ozone levels and varied from less than 1 ppb to 4 ppb.

During most of the flight days, moderate winds from the northwest produced a well-defined, broad ozone plume downwind of Atlanta by mid-afternoon. Ozone levels in the 130-160 ppb range were commonly observed within the mixed layer 35 to 45 miles from the urban core. These concentrations were generally 50 to 70 ppb above background concentrations.

Stagnant wind conditions produced by a stationary front over Atlanta created the worst-case ozone formation of all the study days. Winds were light and variable, and the vertical mixing height was limited to approximately 3000 ft during the day. Unlike the days with northwesterly winds, maximum ozone concentrations were observed in the city at the surface and aloft. The maximum O_3 concentration recorded with the aircraft was approximately 190 ppb on July 24. The hourly averaged maximum at the surface on that day was 172 ppb. Outside of urban Atlanta, the maximum surface concentration was 120 ppb.

EKMA EVALUATION

Ozone production during the two types of wind conditions were modeled using city specific EKMA with the OZIPP computer code. Model input data were taken from surface and aircraft measurements during each modeled day. Maximum ozone concentrations predicted with OZIPP were approximately 10% less than those observed. In addition, a simple air trajectory analysis based upon available surface and upper air data indicated that the predicted ozone maxima occurred very near the locations and times where ozone maxima were actually observed. Results from three SF_6 tracer tests also indicated that predicted trajectories correctly simulated gas transport paths originating in Atlanta and extending as far as 45 miles downwind.

EPA/600/3-88/013 [illegible] p-5

PRECURSOR EMISSION INVENTORIES

Anthropogenic HC and NO_x emissions in Atlanta, recently inventoried by the State of Georgia, are predominately from mobile sources. Annual average emission rates from all sources for a 97 km x 97 km (60 mi x 60 mi) area centered over Atlanta are 133,000 tons HC/year and 275,000 tons NO_x/year. These values yield an HC/NO_x ratio equal to 1.5:1 which is significantly less than observed in the ambient concentrations. Application of a simple box model of the urban area predicted an NO_x concentration essentially equal to the mean observed NO_x concentration. However, predicted hydrocarbon concentrations for the same conditions were 5.0 times less than the mean observed concentration. The results suggest that the discrepancy in the HC/NO_x ratio is the result of severe underestimation of anthropogenic HC emission rates.

Biogenic HC emission rates from the predominate tree species in Atlanta were measured using a branch enclosure technique. Results from 20 samples were similar in magnitude and temperature response to measurements conducted elsewhere in the U.S. At 27°C, the isoprene emission rate from several deciduous species was 11 μg/g/hr, and the alpha-pinene emission rate from loblolly pine was 0.7 μg/g/hr. These rates were combined with biomass density factors to yield emission flux estimates for deciduous and coniferous forests. In turn, land use distributions for Atlanta obtained from an EPA analysis of Landsat data were used with the estimated fluxes to estimate the daily average emission rate: 330 tons/day for isoprene and 24 tons/day for alpha-pinene. On a unit area basis, these rates become 2500 $\mu g/m^2 \cdot hr$ and 90 $\mu g/m^2 \cdot hr$, respectively. For comparison, the average (3.2 km x 3.2 km grid) flux of anthropogenic HC for the 97 km x 97 km area was 1350 $\mu g/m^2 \cdot hr$ and the highest gridded flux of anthropogenic hydrocarbons was 26,600 $\mu g/m^2 \cdot hr$. Unlike the results for the anthropogenic emissions, biogenic HC concentrations predicted with the box model represented an upper bound on typical measured levels.

SECTION 3

EXPERIMENTAL PROCEDURES

The data collection phase of this program consisted of a joint effort involving research teams from Washington State University and the Environmental Protection Agency (Environmental Sciences Research Laboratory, Research Triangle Park). Two special field study laboratories and an instrumented aircraft were used to obtain air quality information in the Atlanta region. Parameters that were measured include ozone, oxides of nitrogen, halocarbons, PAN, individual hydrocarbons in the C_2-C_{10} molecular weight range and numerous meteorological parameters. Additional air quality information was obtained from existing monitoring stations operated by federal, state and local agencies. Figure 1 shows the location of surface stations and lists the pollutants that were measured at each site.

Aircraft sampling missions were conducted on 14 days during the study period. Two flights were flown on most of the 14 days. An early morning flight was designed to establish boundary conditions on the upwind side of Atlanta. The morning mixing height as well as ozone and oxidant precursor transport aloft were monitored during the morning flight. Afternoon flights were conducted in the region downwind of Atlanta to establish dimensions of the urban plume and to locate the region of maximum ozone buildup.

A complete description of the air quality instrumentation employed, calibration methods and data processing and validation procedures is included in Appendix A.

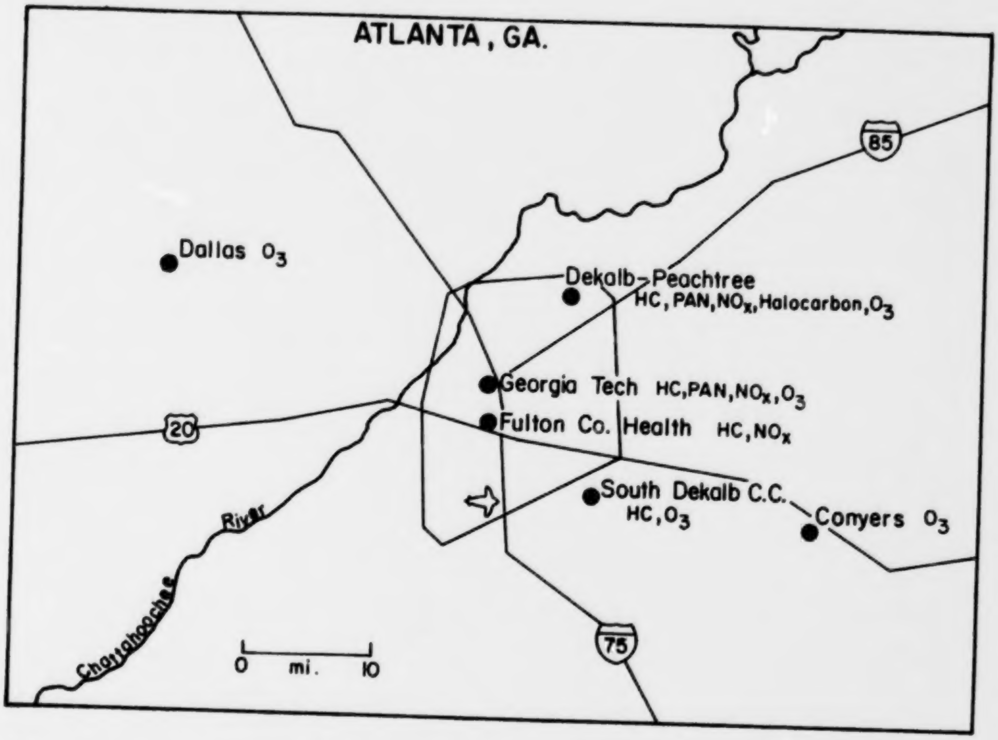


Figure 1. Location of ground level sampling sites in Atlanta.

SECTION 4

RESULTS AND DISCUSSION

METEOROLOGY

Weather patterns during most of the 1981 study period were governed by high pressure systems located to the south of Georgia over the Gulf of Mexico. Consequently, gradient air flow into the Atlanta region consisted of southern air parcels that probably originated over the Gulf of Mexico and passed over portions of Texas, Louisiana, Arkansas and Mississippi prior to arriving in northern Georgia. Figure 2 shows a portion of the daily weather map for July 20, 1981. The position of the high pressure system is typical of that encountered during much of the study period.

During late July, one of the continental highs that originate in Canada and migrate across the upper midwest and eastern U.S. during the summer months penetrated as far south as the Atlanta region. As a consequence of this northern air mass, a stationery front developed over Atlanta. This resulted in a period of low ventilation which persisted for a few days around July 24.

The high pressure systems contributed to fair weather conditions with minimal rainfall and above average temperatures. The average daily maximum temperature on aircraft flight days was 33.8°C, while the normal daily maximum in July is 30.6°C (1). On nineteen days, the temperature exceeded 32°C; normally this temperature is exceeded only on five days in July. The long-term average daily solar radiation during July is 526 ly; during July, 1981, an average value of 528 ly was calculated.

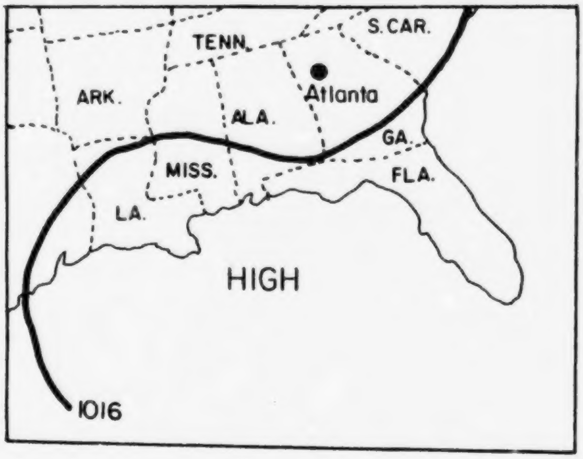


Figure 2. Map showing location of high pressure system over the Gulf of Mexico.

The general meteorological pattern on most sampling days was quite typical of the southeastern U.S. Moderate to strong surface inversions were recorded in National Weather Service (NWS) radiosonde observations taken at 7:00 a.m. EDT near Athens, GA. These inversions varied in depth from very near the surface up to approximately 2000 ft. The inversions quickly eroded during the morning, and the surface mixed layer grew to approximately 5000 ft by mid-afternoon. As the mixing height increased, the winds in the mixed layer typically increased from 2-4 mph in the morning to 9-11 mph by noon. During most of the sampling days, the winds were relatively steady from the northwest.

Meteorological data for specific days are listed in Appendices to this report. Appendix B contains hourly average wind speed and direction, temperature, dew point and solar radiation levels measured at the DeKalb-Peachtree site. Appendix C provides a summary of upper level wind information from pibals released at the DeKalb-Peachtree airport. Tabulations of meteorological data gathered at Georgia Tech by the School of Geophysical Sciences are included in Appendix D. Mixing height information is available from vertical aircraft sounding plots and from morning and afternoon NWS radiosonde data.

OZONE PRECURSOR EMISSIONS

Hydrocarbons

Ambient nonmethane hydrocarbon data were recorded at four sites (Figure 1) in urban Atlanta during the 1981 study period. Integrated samples spanning the 0600-0900 and 1100-1400 time periods were collected on most days at each of the four surface sites. Individual hydrocarbon identities were established through a comparison of retention times and mass spectrometric fragmentation patterns. Using these procedures about 75 hydrocarbon species can be positively identified. This normally corresponds to about 85% of the individual hydrocarbon total in ambient samples. Table 1 shows a typical example of the hydrocarbon information obtained from each analysis. As shown, identified hydrocarbons totaled 195 ppbC in this sample collected at the DeKalb-Peachtree site. The small unidentified peaks in the chromatogram amounted to an additional 27 ppbC. Therefore, a total nonmethane hydrocarbon concentration of 222 ppbC was present in this sample, 87% of which consisted of known species.

A complete tabulation of hydrocarbon data for all surface samples collected in the Atlanta area during the 1981 study period is stored on computer tapes (2). Information similar to that illustrated in Table 1 is provided for each sample. In order to summarize these hydrocarbon data, a series of tables have been prepared which illustrate notable features.

Table 2 lists the nonmethane hydrocarbon totals, including unknowns, measured during the morning hours at the four ground sites. Concentrations varied from 113 to 1677 ppbC with highest levels generally recorded at the Georgia Tech and Fulton County Health Dept. sites.

The mean value of 491 ppbC for the 6-9 a.m. period in Atlanta is somewhat below the comparable NMHC totals recorded in other U.S. cities. Table 3 provides a listing of average NMHC levels measured between 6-9 a.m. in several large metropolitan areas.

A listing of the hydrocarbon composition by class (olefin, aromatic and paraffin) is provided in Table 4. Olefinic, aromatic and paraffinic content at the four sites was very similar. Tables 5, 6, 7 and 8 show daily and average concentrations for several of the most abundant hydrocarbons. Standard deviations included in this table indicate that individual hydrocarbon

TABLE 1. INDIVIDUAL HYDROCARBON CONCENTRATIONS MEASURED BETWEEN 7:30 - 9:00 a.m. at THE DEKALB-PEACHTREE SITE ON JULY 17, 1981.

ppbC	Hydrocarbon	ppbC	Hydrocarbon
8.0	Ethane	4.0	2,3-Dimethylpentane
13.2	Ethylene	2.1	3-Methylhexane
7.5	Acetylene	-	2,2,3-Trimethylpentane
7.9	Propane	2.3	n-Heptane
4.7	Propene	1.7	Methylcyclohexane
4.8	i-Butane	-	2,4-Dimethylhexane
17.8	n-Butane	4.8	2,3,4-Trimethylpentane
0.6	1-Butene	14.7	Toluene
1.2	i-Butene	-	2,3-Dimethylhexane
2.0	t-2-Butene	1.5	2-Methylheptane
2.4	c-2-Butene	1.8	3-Ethylhexane
22.7	i-Pentane	1.0	n-Octane
10.9	n-Pentane	-	Ethylcyclohexane
-	1-Pentene	3.2	Ethylbenzene
-	t-2-Pentene	10.2	p & m-Xylene
-	c-2-Pentene	-	Styrene
-	Cyclopentene	1.5	o-Xylene
1.3	Cyclopentane	2.3	n-Nonane
2.0	2,3-Dimethylbutane	-	i-Propylbenzene
7.2	2-Methylpentane	-	n-Propylbenzene
-	c-4-Methyl-2-pentene	2.2	p-Ethyltoluene
4.2	3-Methylpentane	1.5	m-Ethyltoluene
-	1-Hexene	1.5	o-Ethyltoluene
4.6	n-Hexane	1.2	1,3,5-Trimethylbenzene
-	t-2-Hexene	-	1,2,4-Trimethylbenzene
-	c-2-Hexene	-	1,2,3-Trimethylbenzene
3.5	Methylcyclopentane	-	Methylstyrene
3.0	2,4-Dimethylpentane	-	1,3-Diethylbenzene
5.8	Benzene	-	1,4-Diethylbenzene
1.3	Cyclohexane		

Total Identified Hydrocarbons	ppbC		ppbC
Σ Olefin	13	Total Unidentified Hydrocarbons	27.0
Σ Aromatic	21		
Σ Paraffin	62	Total NMHC by summing individual species	222
Acetylene	4		

Table 2. 0600-0900 NONMETHANE HYDROCARBON CONCENTRATIONS (ppbC) OBTAINED BY SUMMING THE INDIVIDUAL SPECIES

Date	DeKalb-Peachtree	Georgia Tech	Fulton Co.	DeKalb CC	
7/13	599	552	384	472	
7/14	393	458	214	425	
7/15	336	451	388	-	
7/16	374	-	-	-	
7/17	148	503	768	352	
7/18	-	-	-	-	
7/19	-	216	466	161	
7/20	466	442	818	325	
7/21	248	384	575	224	
7/22	229	640	-	527	
7/23	572	-	506	252	
7/24	310	342	708	209	
7/25	1,677	-	-	-	
7/26	-	1,054	741	663	
7/27	834	915	1,033	621	
7/28	651	767	1,153	664	
7/29	216	-	-	-	
7/30	159	294	539	218	
7/31	270	220	528	180	
8/1	-	-	-	-	
8/2	-	113	298	-	
8/3	293	473	843	227	
$\overline{x}$ ± SD	457±366	489±254	622±260	368±181	485±285

TABLE 3. MEAN NONMETHANE HYDROCARBON CONCENTRATIONS (ppbC) MEASURED BETWEEN 6-9 a.m. IN EIGHT URBAN AREAS

City	Mean NMHC	Range of Concentrations	Number of Samples
Houston	1414	356-16284	36
Newark	732	89-6946	132
Washington, DC	671	210-2953	64
Philadelphia	669	205-1710	82
Baltimore	659	51-2798	140
Boston	569	83-4750	160
Atlanta	491	113-1677	44
Milwaukee	324	24-3116	150

TABLE 4. PERCENTAGE DISTRIBUTION OF HYDROCARBONS BY CLASS IN SAMPLES COLLECTED AT ATLANTA SITES DURING THE 6-9 a.m. PERIOD

	Georgia Tech	Fulton County Health Dept.	DeKalb CC	DeKalb-Peachtree
Paraffin	52±7	52±5	52±5	66±6
Olefin	14±3	14±2	17±7	12±2
Aromatic	35±9	34±6	30±4	20±3

TABLE 5. AVERAGE CONCENTRATION (ppbC) OF SELECTED HYDROCARBONS AT DEKALB-PEACHTREE (0600-0900)*

	7/13	7/14	7/15	7/16	7/17	7/20	7/21	7/22	7/23
Ethane	8.0	8.2	6.2	7.0	7.5	38.0	11.8	7.8	7.1
Acetylene	11.3	9.7	6.3	10.3	4.9	12.6	7.8	6.2	8.7
Propane	11.2	8.9	7.4	12.1	6.6	12.3	6.8	7.1	20.8
Propene	7.9	6.1	3.3	6.5	4.5	6.5	4.4	5.1	7.2
i-Butane	14.5	5.9	2.9	8.0	7.1	10.7	5.4	4.9	22.4
n-Butane	49.2	20.7	14.8	28.2	25.5	39.5	18.2	16.2	89.6
1-Butene	0.7	0.8	0.7	0.6	0.8	0.8	0.8	0.7	0.9
i-Butene	3.1	1.6	1.2	1.9	1.7	2.3	1.3	1.5	4.3
t-2-Butene	4.1	3.5	3.4	2.6	2.2	2.9	2.0	2.0	5.8
i-Pentane	58.6	26.5	21.3	35.9	28.7	44.0	24.9	22.1	98.5
n-Pentane	36.4	24.5	15.0	20.3	11.8	17.3	11.4	9.3	33.8
Cyclopentane	4.7	1.5	-	1.9	1.4	2.1	1.3	1.2	3.3
2,3-Dimethylbutane	9.4	1.7	1.4	2.3	2.0	3.2	2.2	2.1	4.2
2-Methylpentane	15.3	9.0	8.9	11.8	6.8	10.3	6.9	5.9	16.7
3-Methylpentane	12.0	5.3	5.5	7.0	4.4	6.6	4.3	3.7	11.6
n-Hexane	14.6	8.2	6.1	7.5	4.4	6.6	4.8	3.6	20.1
Methylcyclopentane	8.5	3.7	2.8	5.8	2.9	4.5	3.4	2.8	17.4
Benzene	10.0	7.5	5.4	8.5	4.7	7.0	4.7	4.3	7.3
2-Methylhexane	8.9	6.0	5.1	7.1	4.0	5.4	4.4	4.0	7.4
3-Methylhexane	4.5	3.0	3.3	3.5	2.7	2.5	1.9	1.8	3.6
n-Heptane	2.3	3.4	3.5	3.9	3.0	6.0	1.8	2.9	3.9
Methylcylohexane	4.0	3.5	2.5	2.7	1.2	1.7	1.8	1.8	3.1
Toluene	30.4	23.9	17.6	23.1	13.5	19.7	16.0	12.6	23.3
2-Methylheptane	3.1	2.4	1.8	2.3	1.3	2.0	1.7	1.6	3.2
3-Methylheptane	2.5	1.2	2.1	2.1	2.5	2.5	1.7	1.4	1.8
n-Octane	1.7	1.5	1.5	1.5	0.8	1.5	0.9	1.1	1.5
Ethylbenzene	5.4	4.5	3.6	4.3	2.8	5.7	2.4	0.9	3.7
p & m-Xylene	16.6	13.1	11.4	12.1	6.8	13.5	7.6	2.7	10.6
o-Xylene	7.1	6.3	4.7	5.1	2.6	5.1	3.2	-	4.1
o-Ethyltoluene	5.5	3.6	2.3	2.7	3.0	-	1.3	2.3	2.1
1,2,4-Trimethylbenzene	-	-	-	-	-	-	-	-	-

(continued)

TABLE 5. continued

	7/24	7/25	7/27	7/28	7/29	7/30	7/31	8/3	$\overline{x}$	±SD
Ethane	5.7	8.7	17.7	14.8	6.9	7.7	6.9	5.5	10.3	7.8
Acetylene	4.4	3.4	19.4	20.8	7.0	5.2	6.5	7.7	9.0	4.9
Propane	10.0	34.1	30.9	17.4	11.0	9.4	8.5	13.2	13.4	8.1
Propene	4.2	6.8	12.1	11.5	4.8	3.3	4.0	6.9	6.2	2.5
i-Butane	14.0	65.0	20.2	18.3	7.8	4.1	7.7	7.9	13.3	14.5
n-Butane	31.7	220	69.0	55.2	23.3	13.3	29.3	25.5	45.2	49.6
1-Butene	0.9	0.8	0.7	0.8	0.8	0.4	0.6	0.8	0.7	0.1
i-Butene	1.8	7.9	4.0	3.9	1.7	0.9	2.0	2.3	2.6	1.7
t-2-Butene	1.7	7.7	5.3	5.2	2.1	1.6	2.0	4.6	3.5	1.8
i-Pentane	43.7	261	85.6	78.8	27.5	16.1	33.0	33.3	55.3	58.3
n-Pentane	20.7	197	53.7	35.9	13.0	7.3	15.2	16.1	31.7	44.3
Cyclopentane	1.9	8.7	4.5	4.5	1.6	0.7	1.6	1.7	2.7	2.1
2,3-Dimethylbutane	1.4	15.9	6.5	6.7	2.3	1.2	2.2	2.7	4.0	3.8
2-Methylpentane	7.4	67.4	18.2	21.8	7.4	4.1	7.3	8.0	13.7	14.7
3-Methylpentane	10.4	42.0	14.6	13.9	4.9	3.0	4.7	5.3	9.4	9.2
n-Hexane	7.8	48.0	18.4	15.8	-	3.0	3.5	3.8	11.0	11.3
Methylcyclopentane	7.1	30.3	11.6	11.2	3.7	2.9	3.6	3.7	7.8	7.5
Benzene	5.9	24.6	17.0	14.8	4.6	2.3	3.6	4.2	8.0	5.8
2-Methylhexane	5.8	31.4	15.1	14.4	3.6	1.9	3.3	4.2	4.2	2.3
3-Methylhexane	3.1	16.9	7.8	6.7	1.8	0.7	1.5	2.0	4.0	3.8
n-Heptane	0.7	11.5	7.2	5.1	1.4	0.8	0.1	2.5	3.5	2.8
Methylcylohexane	3.2	7.6	6.6	4.9	1.7	0.8	2.0	2.3	3.0	1.9
Toluene	14.3	50.2	53.2	47.7	15.6	9.0	12.5	12.9	23.2	14.0
2-Methylheptane	1.1	4.4	3.7	4.4	1.5	1.2	1.7	1.3	2.3	1.1
3-Methylheptane	1.7	5.8	3.2	3.7	1.5	0.9	1.7	1.5	2.2	1.2
n-Octane	1.5	3.3	3.8	2.4	0.8	0.4	0.6	1.0	1.5	0.9
Ethylbenzene	1.1	7.9	10.0	6.6	3.0	1.8	2.2	3.0	4.1	2.4
p & m-Xylene	2.2	27.8	28.2	18.7	-	6.2	6.9	8.0	12.0	7.7
o-Xylene	-	23.7	11.4	7.6	3.8	2.5	2.9	3.0	6.2	5.4
o-Ethyltoluene	1.9	47.8	6.8	4.1	1.9	1.7	1.2	1.5	5.6	11.4
1,2,4-Trimethylbenzene	-	-	-	-	-	-	-	-	-	-

* - Analysis by Washington State University

TABLE 6. AVERAGE CONCENTRATION (ppbC) OF SELECTED HYDROCARBONS AT FULTON COUNTY (0600-0900) #

	7/13	7/14	7/15	7/17	7/19	7/20	7/21	7/23	7/24
Ethane	7.0	8.3	12.3	10.6	11.7	13.1	8.7	27.8	11.5
Acetylene	9.0	10.4	9.2	14.0	11.3	23.8	18.6	19.7	29.0
Propane	7.3	7.3	13.0	9.4	15.8	16.1	6.3	17.3	8.6
Propene	2.2	4.3	3.1	4.9	4.4	10.8	9.7	11.1	13.6
i-Butane	6.2	9.6	8.9	10.0	7.6	13.2	9.8	27.7	14.3
n-Butane	22.1	22.5	29.4	36.2	26.3	55.0	39.4	92.5	57.9
1-Butene	4.2	.0	5.5	7.1	5.3	12.0	9.1	10.8	12.1
i-Butene	*	*	*	*	*	*	*	*	*
t-2-Butene	1.7	.0	1.1	2.9	2.0	5.9	3.2	4.4	4.1
i-Pentane	29.1	.0	35.3	45.0	34.0	71.5	52.9	25.7	76.9
n-Pentane	15.0	.0	18.3	21.7	16.0	36.0	26.5	38.7	39.5
Cyclopentane	2.2	.0	3.0	3.6	3.2	6.6	4.9	6.8	7.1
2,3-Dimethylbutane	+	+	+	+	+	-	+	+	+
2-Methylpentane	8.9	.0	11.9	15.0	11.5	25.1	18.8	25.7	26.1
3-Methylpentane	5.1	.0	7.2	8.9	6.9	15.0	11.1	15.8	15.9
n-Hexane	7.2	.0	8.5	9.9	5.9	14.5	10.9	13.3	14.9
Methylcyclopentane	5.4	.0	7.3	8.9	7.4	16.1	12.1	14.6	27.8
Benzene	63.3	127.6	17.8	15.0	13.4	32.3	23.3	49.8	28.8
2-Methylhexane	7.4	.0	13.7	9.2	8.2	14.0	16.1	8.8	13.0
3-Methylhexane	4.4	.0	13.3	7.9	4.8	10.1	9.9	7.4	12.2
n-Heptane	1.8	.0	9.7	4.4	2.4	5.8	4.5	3.9	5.2
Methylcylohexane	.8	.0	3.7	3.5	2.2	4.7	5.6	2.6	5.0
Toluene	33.6	24.6	63.1	57.3	19.9	58.1	48.8	46.2	58.7
2-Methylheptane	-	-	-	-	-	-	-	-	-
3-Methylheptane	-	-	-	-	-	-	-	-	-
n-Octane	-	-	-	-	-	-	-	-	-
Ethylbenzene	3.4	4.4	5.0	6.1	9.2	14.7	6.7	9.3	10.6
p & m-Xylene	6.0	5.9	7.4	9.1	16.1	20.0	13.0	14.3	27.4
o-Xylene	6.2	4.4	6.0	7.6	12.8	15.8	9.3	12.0	12.7
o-Ethyltoluene	2.8	1.8	2.4	2.0	3.2	5.9	3.5	3.8	3.2
1,2,4-Trimethylbenzene	7.0	7.1	7.8	8.5	8.0	29.6	12.1	.0	.0

(continued)

TABLE 6. continued

	7/26	7/27	7/28	7/30	7/31	8/2	8/3	$\overline{x}$	±SD
Ethane	13.9	28.0	16.1	12.5	10.1	6.5	13.0	13.2	6.3
Acetylene	22.4	38.1	39.1	15.1	20.9	9.3	37.1	20.4	10.5
Propane	14.3	16.8	22.1	10.5	5.2	4.0	10.9	11.6	5.1
Propene	11.2	18.5	18.7	7.0	10.0	4.1	18.4	9.5	5.6
i-Butane	13.9	20.7	20.3	18.2	7.5	4.9	16.1	12.9	6.2
n-Butane	49.7	80.0	79.8	60.5	30.0	16.6	60.2	47.3	23.2
1-Butene	8.5	17.8	17.3	9.4	8.7	4.1	16.9	9.9	4.6
i-Butene	*	*	*	*	*	*	*		
t-2-Butene	3.3	6.0	6.1	3.8	2.7	1.6	4.8	3.3	1.9
i-Pentane	45.8	108.2	108.5	60.7	45.4	24.0	83.4	53.0	30.4
n-Pentane	27.1	55.2	58.7	31.2	25.0	13.9	36.0	30.6	13.7
Cyclopentane	4.8	9.0	9.7	3.6	3.8	2.1	7.2	5.2	2.4
2,3-Dimethylbutane	+	+	+	+	+	+	+		
2-Methylpentane	18.8	37.5	38.3	19.5	16.4	2.1	28.1	20.2	10.1
3-Methylpentane	10.9	22.4	24.8	11.6	9.9	5.3	16.8	12.5	5.9
n-Hexane	12.4	23.0	28.2	11.6	9.8	6.0	16.3	12.8	6.1
Methylcyclopentane	11.7	23.4	30.1	10.9	10.7	5.2	18.8	13.2	8.3
Benzene	48.3	49.3	23.3	21.0	37.7	20.9	55.1	39.2	6.3
2-Methylhexane	9.8	15.7	6.4	9.0	6.4	5.3	13.0	10.4	3.6
3-Methylhexane	7.1	14.9	6.4	7.4	7.6	4.2	12.8	8.7	3.4
n-Heptane	4.0	8.2	2.7	5.6	3.9	5.6	5.5	4.9	2.1
Methylcylohexane	3.8	7.9	1.7	4.3	3.8	2.1	5.8	3.7	2.0
Toluene	41.7	80.9	42.2	31.2	46.3	19.7	70.2	46.4	17.8
2-Methylheptane	-	-	-	-	-	-	-		
3-Methylheptane	-	-	-	-	-	-	-		
n-Octane	-	-	-	-	-	-	-		
Ethylbenzene	6.0	14.0	6.5	4.5	8.3	3.1	10.7	7.7	2.5
p & m-Xylene	8.9	14.3	6.9	6.7	12.2	5.0	17.1	11.9	6.2
o-Xylene	8.4	19.7	8.8	7.6	12.1	5.3	14.7	10.2	4.3
o-Ethyltoluene	2.4	4.7	2.5	2.1	2.9	1.9	4.6	3.1	1.2
1,2,4-Trimethylbenzene	.0	.0	12.0	8.4	13.2	5.9	.0	10.9	6.7

- Analysis by EPA

* - Combined with 1-Butene

+ - Combined with Cyclopentane

TABLE 7. AVERAGE CONCENTRATION (ppbC) OF SELECTED HYDROCARBONS AT GEORGIA TECH (0600-0900)#

	7/13	7/14	7/15	7/17	7/19	7/20	7/21	7/22	7/23
Ethane	11.3	8.8	12.3	9.7	10.2	13.7	8.4	17.8	12.9
Acetylene	9.1	5.8	9.2	10.8	3.5	11.7	12.3	40.0	19.0
Propane	11.4	12.5	13.0	11.7	8.4	11.9	7.7	16.0	13.7
Propene	4.7	3.4	3.1	4.6	0.9	5.6	5.8	9.7	5.4
i-Butane	7.5	6.2	8.9	7.5	5.1	6.9	5.9	14.2	9.1
n-Butane	26.9	20.7	29.4	26.6	18.4	21.3	18.3	43.9	28.1
1-Butene	0.1	3.3	5.5	5.2	2.7	5.5	4.8	9.7	6.5
i-Butene	*	*	*	*	*	*	*	*	*
t-2-Butene	0.9	0.5	1.1	1.8	1.2	1.2	1.6	2.9	1.9
i-Pentane	34.9	23.5	35.3	28.5	20.4	28.3	25.0	60.3	33.6
n-Pentane	19.7	12.3	18.3	14.8	10.7	15.3	13.6	26.6	18.3
Cyclopentane	2.6	2.2	3.0	2.0	1.5	2.7	4.4	5.0	3.1
2,3-Dimethylbutane	+	+	+	+	+	+	+	+	+
2-Methylpentane	11.8	8.6	11.9	8.6	6.5	10.7	9.9	19.5	13.1
3-Methylpentane	6.8	4.4	7.2	7.0	3.8	6.5	9.4	12.5	7.6
n-Hexane	7.1	5.3	8.5	6.3	3.7	7.3	21.1	13.3	8.1
Methylcyclopentane	6.6	4.1	7.3	6.8	3.2	6.4	8.8	12.3	7.3
Benzene	15.7	11.7	17.8	15.7	6.6	16.5	15.6	34.3	21.4
2-Methylhexane	4.5	0.1	13.7	7.7	6.2	7.6	6.3	11.8	6.7
3-Methylhexane	7.5	17.8	13.3	7.4	2.5	5.8	4.5	13.7	6.7
n-Heptane	5.9	12.7	9.7	3.3	1.8	2.9	2.9	6.3	2.2
Methylcylohexane	2.3	3.7	3.7	3.0	0.5	2.5	2.2	5.1	3.4
Toluene	87.9	169.	63.1	52.2	12.9	29.8	31.1	68.2	42.3
2-Methylheptane	-	-	-	-	-	-	-	-	-
3-Methylheptane	-	-	-	-	-	-	-	-	-
n-Octane	-	-	-	-	-	-	-	-	-
Ethylbenzene	7.5	2.8	5.0	3.9	1.4	8.3	5.8	8.4	9.5
p & m-Xylene	22.7	8.4	14.9	13.1	4.1	12.6	9.0	11.3	12.0
o-Xylene	8.3	3.4	6.0	5.2	1.6	8.3	6.5	11.8	9.1
o-Ethyltoluene	2.4	1.4	2.4	2.3	.8	3.0	2.9	2.5	1.7
1,2,4-Trimethylbenzene	12.2	6.3	7.8	6.9	2.9	15.1	9.4	9.6	.0

(continued)

TABLE 7. continued

	7/24	7/28	7/30	7/31	8/2	8/3	$\overline{x}$	±SD
Ethane	7.1	22.5	21.3	7.4	4.9	14.5	12.6	5.1
Acetylene	7.8	37.8	6.4	9.2	3.5	18.7	13.7	11.2
Propane	7.4	26.6	11.9	4.9	3.6	11.4	11.9	5.4
Propene	3.2	11.0	3.2	2.3	1.2	7.6	4.8	2.9
i-Butane	7.4	14.5	8.6	6.6	2.4	9.1	8.0	3.1
n-Butane	25.1	44.5	33.4	23.6	6.6	30.0	26.5	9.6
1-Butene	4.2	10.0	4.0	3.9	1.0	7.9	5.0	2.8
i-Butene	*	*	*	*	*	*	*	*
t-2-Butene	1.8	3.3	1.9	1.7	0.5	2.8	1.7	0.8
i-Pentane	27.7	59.5	28.4	26.0	8.5	44.9	32.3	13.7
n-Pentane	16.2	32.2	14.3	14.0	5.8	24.8	17.1	6.6
Cyclopentane	2.3	5.3	1.9	1.6	1.0	3.3	2.8	1.3
2,3-Dimethylbutane	+	+	+	+	+	+	+	+
2-Methylpentane	9.2	21.4	7.3	7.7	2.8	13.5	10.8	4.8
3-Methylpentane	5.2	12.9	4.4	4.8	1.8	9.0	6.9	3.1
n-Hexane	5.0	14.3	4.4	5.1	2.1	8.6	7.4	3.5
Methylcyclopentane	4.6	14.5	4.0	4.2	1.3	8.5	6.7	3.5
Benzene	10.8	30.1	10.6	12.2	5.6	17.2	16.1	7.8
2-Methylhexane	5.9	12.7	4.3	4.1	2.1	6.7	6.7	3.7
3-Methylhexane	5.2	12.9	3.4	4.8	1.1	5.7	7.5	4.8
n-Heptane	1.9	7.8	2.2	1.8	.8	2.8	4.3	3.4
Methylcylohexane	1.5	5.7	1.3	1.5	.8	3.2	2.7	1.5
Toluene	15.9	61.5	20.8	14.5	6.7	31.0	47.1	41.2
2-Methylheptane	-	-	-	-	-	-	-	-
3-Methylheptane	-	-	-	-	-	-	-	-
n-Octane	-	-	-	-	-	-	-	-
Ethylbenzene	4.2	11.2	3.4	2.4	1.2	4.5	5.3	3.1
p & m-Xylene	7.0	16.8	4.1	3.5	2.4	7.4	10.0	5.6
o-Xylene	5.0	11.2	4.6	3.4	2.7	7.8	6.3	3.0
o-Ethyltoluene	.9	3.8	1.3	.6	1.0	2.1	1.9	0.9
1,2,4-Trimethylbenzene	4.3	14.0	4.5	1.6	2.7	.0	7.5	4.4

# - Analysis by EPA

* - Combined with 1-Butene

+ - Combined with Cyclopentane

TABLE 8. AVERAGE CONCENTRATION (ppbC) OF SELECTED HYDROCARBONS AT DEKALB CC (0600-0900)#

	7/13	7/14	7/17	7/19	7/20	7/21	7/22	7/23	7/24
Ethane	10.3	3.2	10.8	14.0	9.1	5.1	11.5	8.2	8.0
Acetylene	11.5	9.5	9.5	2.5	5.6	4.7	15.3	6.5	5.4
Propane	14.5	9.5	9.1	8.2	10.7	5.4	12.0	7.1	6.7
Propene	7.2	6.3	2.7	1.5	3.5	2.4	7.1	2.7	2.5
i-Butane	9.8	8.5	7.3	3.7	4.7	4.1	10.6	5.5	3.7
n-Butane	25.0	30.9	21.4	10.6	16.1	12.9	41.1	20.2	12.9
1-Butene	6.2	5.9	4.5	1.6	3.9	3.1	7.2	4.1	3.2
i-Butene	*	*	*	*	*	*	*	*	*
t-2-Butene	2.2	2.2	1.7	0.6	1.7	1.1	2.5	1.4	1.3
i-Pentane	45.3	41.5	29.5	12.2	21.3	15.6	48.3	25.7	17.4
n-Pentane	25.0	22.0	20.6	8.9	12.3	7.9	19.3	14.4	10.1
Cyclopentane	3.2	3.1	2.4	1.2	4.1	1.3	4.6	2.3	1.9
2,3-Dimethylbutane	+	+	+	+	+	+	+	+	+
2-Methylpentane	12.8	13.4	10.2	4.1	8.6	5.2	16.4	9.5	6.2
3-Methylpentane	7.1	7.9	6.4	2.5	4.4	3.1	9.7	5.5	3.8
n-Hexane	7.3	9.2	7.1	2.5	4.8	3.9	10.1	5.6	3.8
Methylcyclopentane	7.0	7.3	5.8	2.2	4.3	2.7	10.0	5.3	2.9
Benzene	2.0	16.1	12.1	10.8	9.7	8.4	20.9	11.6	10.4
2-Methylhexane	3.8	7.5	6.0	3.4	5.4	3.4	7.5	4.6	4.6
3-Methylhexane	4.7	6.1	6.6	1.6	4.4	2.4	6.2	3.6	3.3
n-Heptane	2.1	2.7	2.4	0.7	1.8	1.1	3.5	1.6	1.1
Methylcylohexane	2.0	2.6	2.5	0.5	1.0	1.3	3.3	1.1	1.0
Toluene	30.0	26.8	27.2	5.7	17.7	14.5	39.5	16.6	11.9
2-Methylheptane	-	-	-	-	-	-	-	-	-
3-Methylheptane	-	-	-	-	-	-	-	-	-
n-Octane	-	-	-	-	-	-	-	-	-
Ethylbenzene	4.8	7.1	2.7	1.8	5.0	3.1	5.2	2.4	7.0
p & m-Xylene	6.7	6.8	5.3	2.8	7.5	4.1	13.2	8.9	3.7
o-Xylene	5.6	5.5	4.8	3.5	4.9	3.3	9.0	4.4	2.9
o-Ethyltoluene	1.9	1.8	2.1	0.7	2.1	1.9	2.8	1.2	1.4
1,2,4-Trimethylbenzene	1.1	8.3	7.0	3.3	9.6	4.2	12.5	.0	.0

(continued)

TABLE 8. continued

	7/26	7/27	7/28	7/30	7/31	8/3	$\overline{x}$	±SD
Ethane	18.6	14.9	9.1	9.0	6.4	13.9	10.1	4.0
Acetylene	9.4	13.7	11.9	4.2	5.4	6.4	8.1	2.6
Propane	17.8	10.6	14.9	6.8	3.9	8.3	9.7	3.8
Propene	3.1	7.3	7.8	10.4	2.7	3.9	4.7	2.7
i-Butane	9.4	10.6	12.8	5.2	3.1	5.6	7.0	3.1
n-Butane	37.0	41.6	44.0	15.7	10.8	15.8	23.7	12.1
1-Butene	5.1	15.8	8.7	3.2	2.7	3.4	5.2	3.5
i-Butene	*	*	*	*	*	*	*	*
t-2-Butene	1.8	3.2	3.3	1.8	1.2	1.6	1.8	0.7
i-Pentane	43.7	50.9	57.1	20.1	14.5	25.4	31.2	15.1
n-Pentane	10.0	29.2	24.5	7.5	10.1	16.9	15.9	7.1
Cyclopentane	3.5	4.1	5.4	1.5	1.2	1.8	2.8	1.3
2,3-Dimethylbutane	+	+	+	+	+	+	+	+
2-Methylpentane	16.4	17.0	21.6	6.1	5.3	7.2	10.7	5.3
3-Methylpentane	8.7	9.9	12.3	4.1	2.8	4.1	6.2	3.0
n-Hexane	9.7	10.3	12.3	3.9	3.2	4.1	6.5	3.1
Methylcyclopentane	7.8	9.8	11.2	3.0	2.8	4.0	5.7	3.0
Benzene	21.4	20.4	23.3	9.4	6.9	13.5	13.1	6.1
2-Methylhexane	7.5	6.5	6.4	3.8	2.9	3.4	5.1	1.7
3-Methylhexane	5.5	8.5	6.4	2.8	3.5	2.4	4.5	2.0
n-Heptane	2.8	3.2	2.7	1.4	1.2	1.0	2.0	0.9
Methylcylohexane	3.3	3.0	1.7	1.4	1.4	.9	1.8	0.9
Toluene	33.4	32.1	42.2	11.7	10.8	12.6	22.2	11.5
2-Methylheptane	-	-	-	-	-	-	-	-
3-Methylheptane	-	-	-	-	-	-	-	-
n-Octane	-	-	-	-	-	-	-	-
Ethylbenzene	5.5	8.2	6.5	1.7	2.1	2.0	4.3	2.2
p & m-Xylene	11.4	9.8	9.9	2.6	2.4	3.4	6.6	3.5
o-Xylene	8.2	8.5	8.8	2.6	3.2	2.8	5.2	2.3
o-Ethyltoluene	2.8	3.2	2.5	1.3	1.6	.7	1.9	0.7
1,2,4-Trimethylbenzene	.0	.0	12.0	3.1	5.6	.0	6.7	3.9

- Analysis by EPA

* - Combined with 1-Butene

+ - Combined with Cyclopentane

concentrations varied considerably from day to day. In most cases, the standard deviation was about half of the mean. Even though considerable variation is observed for individual concentrations the percentage composition shown in Table 4 indicates rather consistent composition, perhaps suggesting consistency in source emissions.

Oxides of Nitrogen and NMHC/NO_x Ratios

A listing of the 6-9 a.m. NO, NO_2 and NO_x concentrations measured at sites with oxides of nitrogen analyzers is provided in Table 9. Concentration values for NO_x ranged from less than 10 to greater than 200 ppb during the study period. Mean NO_x concentrations recorded at the Georgia Tech, Fulton County Health Dept. and DeKalb-Peachtree sites were 68, 58 and 44 ppb, respectively. It is obvious from Table 9 that the data base at DeKalb-Peachtree is smaller than at the other two sites. Thus, the mean NO_x value at that site might not be truly representative of the entire sampling period. Hydrocarbon/NO_x ratios were calculated for each site by dividing the daily 6-9 a.m. nonmethane hydrocarbon total (Table 2) by the NO_x concentration (Table 9). At the Georgia Tech site, a mean HC/NO_x ratio of 8.2±3.4 was derived from sixteen days when both NMHC and NO_x data were available. Seven days with data at the Fulton County Health Dept. site yielded a HC/NO_x ratio of 8.8±5.7 while a value of 8.7±2.2 was obtained at the DeKalb-Peachtree site based on four days with both hydrocarbon and NO_x data. Combination of the three values gives a mean HC/NO_x ratio of 8.6 for the Atlanta urban area. This ratio falls in the 6-12 range normally reported for large cities in the United States. A median value of 8.5 has been determined from hydrocarbon and NO_x data recorded in 56 cities (3).

Table 9. NO_x CONCENTRATIONS (ppb) MEASURED AT ATLANTA AREA SITES BETWEEN 6-9 a.m.

Date	Georgia Tech			DeKalb-Peachtree			Fulton Co. Health Dept.		
	NO	NO_2	NO_x	NO	NO_2	NO_x	NO	NO_2	NO_x
7/13	32	40	72	18	34	52	-	-	55
7/14	20	32	52	15	35	50	45	65	110
7/15	46	41	87	12	25	37	15	55	70
7/16	21	39	60	23	36	59	18	14	32
7/17	29	40	69	-	-	-	-	-	-
7/18	3	17	20	7	14	21	-	-	7
7/19	0	12	12	-	-	-	-	-	-
7/20	26	32	58	-	-	-	-	-	-
7/21	8	46	54	-	-	-	18	52	70
7/22	62	46	108	-	-	-	20	54	74
7/23	-	-	-	-	-	-	8	57	65
7/24	3	30	33	-	-	-	10	25	35
7/25	17	44	61	-	-	-	-	-	-
7/26	175	39	214	-	-	-	30	35	65
7/27	106	31	137	-	-	-	-	-	-
7/28	80	28	108	-	-	-	-	-	-
7/29	53	22	75	-	-	-	-	-	-
7/30	22	20	42	-	-	-	-	-	-
7/31	7	28	35	-	-	-	-	-	-
8/1	-	-	-	-	-	-	-	-	-
8/2	0	8	8	-	-	-	-	-	-
8/3	40	23	63	-	-	-	-	-	-
$\overline{x}$ ± SD			68±47			44±15			58±28

OXIDANTS

Ozone

Little published information exists in the literature concerning ozone trends and patterns in the Atlanta region. During the period June 1975 - May 1976, the state of Georgia, Fulton County and EPA Region IV collaborated on a transportation pollution study which included ozone monitoring. The maximum one-hour ozone readings recorded during the study period were about 170 ppb and 160 ppb at the DeKalb CC and Fulton County Health Department sites, respectively (4).

Data collected during the 1981 Atlanta study are useful for defining ozone production and transport in the Atlanta region. The mobility added by the aircraft allowed the acquisition of data pertinent to understanding the relative importance of ozone and ozone precursor transport into the Atlanta area vs. ozone production from Atlanta emissions. The special monitoring stations at DeKalb-Peachtree airport and on the Georgia Tech campus provided two additional ground level air quality monitoring sites in metropolitan Atlanta. The NAAQS for ozone (120 ppb) was exceeded at one or more of the surface stations on three days during the 1981 study period. Table 10 provides a summary of hourly average maximum ozone concentrations recorded at each of the five surface monitoring stations during the 22 day study period. The highest hourly value was 172 ppb measured at the DeKalb-Peachtree site on July 24. Four of the five stations equaled or exceeded the ozone standard on that day. The greatest number of exceedances occurred at the Conyers station which is located about 24 miles east of Atlanta. This is not unexpected since the predominantly northwest wind flow carried the Atlanta plume into the vicinity of the Conyers station on most sampling days. The ozone standard was

TABLE 10. DAILY MAXIMUM OZONE CONCENTRATION (ppb-hourly average) RECORDED AT SURFACE SITES IN THE ATLANTA AREA DURING THE 1981 STUDY PERIOD

	Monitoring Site				
Date	Dallas[a]	DeKalb-Peachtree	Georgia Tech	DeKalb C. C.	Conyers[b]
7/13	65	91	87	75	105
7/14	75	97	103	95	130
7/15	65	91	60	100	-
7/16	60	98	74	115	-
7/17	65	93	93	110	130
7/18	70	73	93	-	80
7/19	85	88	112	-	95
7/20	60	88	62	70	110
7/21	65	83	73	70	105
7/22	70	75	84	90	110
7/23	85	99	112	115	95
7/24	95	172	168	145	120
7/25	75	109	89	110	115
7/26	65	108	89	100	105
7/27	65	111	70	75	100
7/28	50	53	47	55	-
7/29	55	68	50	55	-
7/30	65	53	47	45	-
7/31	40	37	31	30	35
8/1	40	33	26	20	30
8/2	55	39	56	30	40
8/3	75	71	75	50	55

[a] 30 miles northwest of Atlanta on highway 278
[b] 24 miles east of Atlanta on highway 212

not exceeded at the Dallas site during the study period. This site is located approximately 30 miles northwest of Atlanta and thus was generally upwind of the urban area.

Daily maximum hourly ozone values at the four monitoring stations are plotted in Figure 3. During the first 10 days of the study period, there existed considerable variation in the daily maximum between stations. Values ranged from about 60 ppb up to 130 ppb with the Conyers station generally reporting the highest concentration. This is not unexpected due to the fact that winds were from the northwest which resulted in transport of Atlanta emissions into the Conyers area. July 24 was a day with low ventilation and,

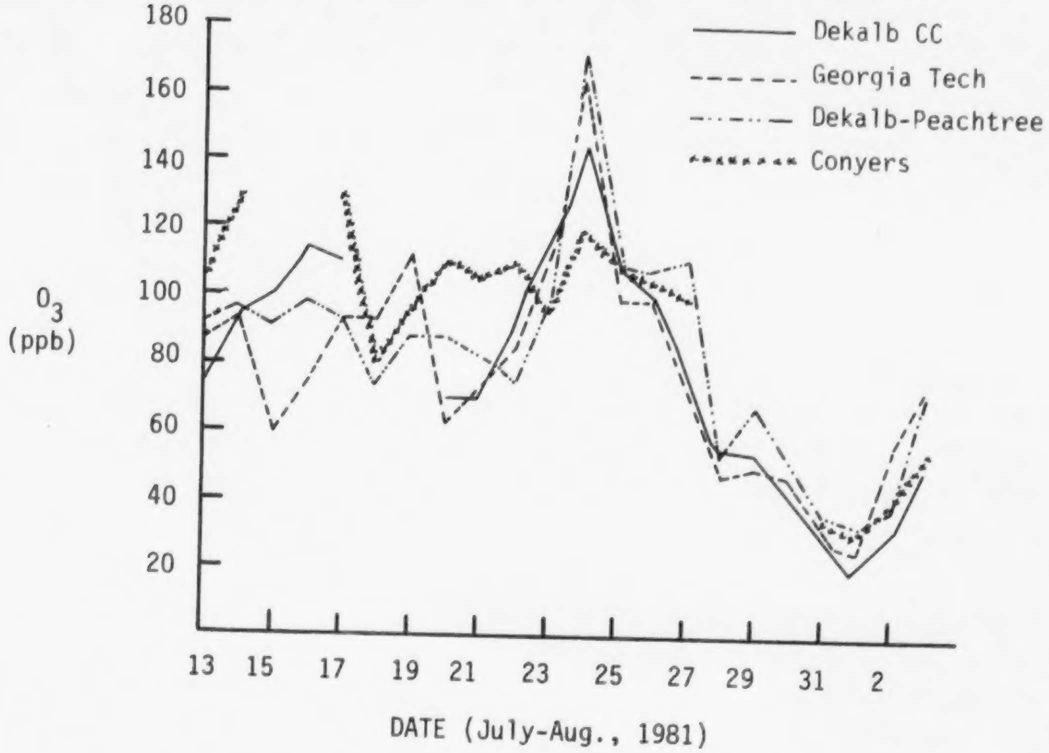


Figure 3. Daily maximum ozone trends at the DeKalb-Peachtree, Georgia Tech, DeKalb CC and Conyers sites.

consequently, ozone levels were highest in urban Atlanta. The maximum daily value ranged from 145 to 172 ppb at the urban stations but only reached 120 ppb at Conyers. Beginning on July 28 and extending to the end of the study period, maximum ozone readings at the four stations were very similar with most maximum values in the 30-60 ppb range. Much of this latter portion of the study period was characterized by cloudy weather with below normal solar insolation. Figure 4 shows a plot of the mean maximum hourly average ozone concentration recorded at four of the Atlanta area stations (Dallas excluded). On fourteen days the mean maximum value for the four stations fell in the 80-110 ppb range; one day exhibited a mean greater than 150, and on the remaining seven days the mean concentration was less than 60 ppb.

PAN

Ambient peroxyacetyl nitrate concentrations were monitored at the Georgia Tech site from July 11 to August 3. Table 11 summarizes the hourly average PAN concentrations throughout the sampling period. It can be seen that the concentration of this oxidant was generally very low. On about half of the sampling days, PAN levels did not exceed 1.0 ppb with the highest hourly average concentration recorded being only 4.1 ppb. The extremely low levels of PAN during the early morning hours implies that a carry-over of photochemical oxidants from one day to the next did not occur.

PAN levels in Atlanta appear to be lower than those recorded in other urban areas. A maximum hourly average PAN concentration of 11.5 was recorded in Houston during a study in 1976 (5). Lonneman, Bufalini and Seila (6) reported an average PAN concentration of 18.4 in Los Angeles, 6.3 in St. Louis and 3.7 in Hoboken, NJ for the daytime period between 10:00 a.m. and 4:00 p.m.

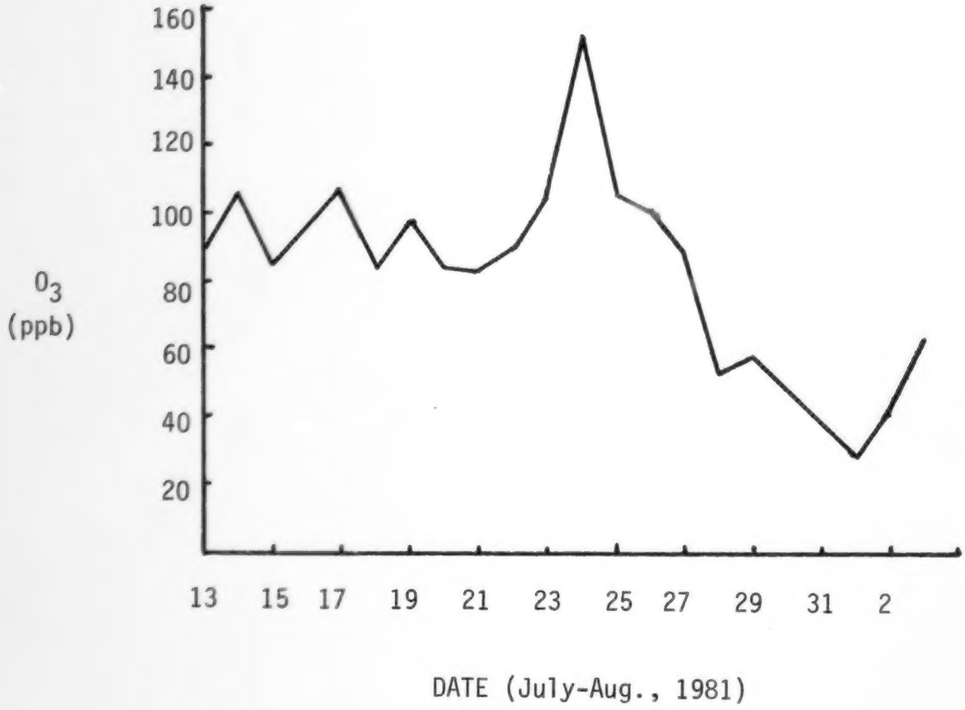


Figure 4. Mean daily maximum ozone concentration for the combined four station network (Dekalb-Peachtree, Georgia Tech, Dekalb CC and Conyers).

Table 11. PAN HOURLY AVERAGE CONCENTRATIONS (ppb) AT THE GEORGIA TECH SITE DURING THE PERIOD JULY 11- AUG. 3, 1981.

Time	Date																						
	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3
0100	.1	.4	.1	.4	.4	.4	*	-	.6	.7	-	.2	.6	.3	.3	.1	.3	.3	.2	.1	.4	.4	.3	.1
0200	.1	.4	.3	.4	.2	.4	.3	.4	.3	.6	-	.2	.6	.3	.3	.2	.3	.2	.2	.1	.4	.4	.3	.2
0300	.1	.3	.3	.4	.2	.3	.3	.3	.5	.7	-	.2	.5	.3	.3	.3	.2	.2	.1	.1	.5	.4	.3	.1
0400	.1	.4	.3	.3	.2	.3	.2	.3	.4	.6	-	.2	.5	.3	.2	.2	.2	.4	.1	.2	.5	.3	.3	.2
0500	.1	.3	.2	.2	.1	.1	.2	.3	.4	.5	-	.2	.5	.3	.3	.1	.1	.3	.1	.1	.4	.3	.3	.1
0600	.1	.3	.2	.2	.2	.1	.2	.4	.3	.5	-	.2	.6	.1	.3	.1	.1	.2	.1	.1	.5	.3	.3	.1
0700	.1	.2	.2	.2	.2	.1	.2	.5	.4	.3	-	.3	.5	.4	.2	*	.1	.1	.1	.1	.6	.3	.3	.1
0800	-	.3	.2	.2	.2	.4	.2	1.1	.4	.3	.1	.4	.4	.3	.2	.1	.1	.1	.1	.1	.5	.3	.3	.1
0900	-	.4	.2	.2	.2	.3	.4	1.2	.4	.8	-	.4	.5	.5	.6	.3	.2	.3	.1	.1	.5	.3	.3	.2
1000	-	-	.6	.5	.5	.5	1.1	-	.7	.8	-	.4	.7	.8	.4	.5	.2	.4	.3	.1	.6	.2	.3	.3
1100	.3	-	.5	.6	.8	.6	1.0	-	1.4	1.0	-	.5	.9	1.0	.5	1.0	.6	.6	.4	.1	.4	.2	.1	.8
1200	1.1	.8	.8	1.0	.8	.6	.9	1.0	2.0	1.0	-	.8	1.0	1.6	.3	1.5	.8	.4	.4	.2	.5	.2	.2	1.0
1300	1.3	.8	.5	1.1	.9	-	.6	1.4	2.2	.9	-	.8	1.5	2.9	.5	1.2	.9	.3	.1	.4	.6	.2	.3	.7
1400	.8	.7	.6	1.1	.6	.5	1.6	1.7	2.8	1.2	-	1.2	1.3	3.5	.4	.9	.6	.4	.4	.5	.3	.2	.5	.9
1500	.6	.7	.5	.8	.8	.3	2.0	1.9	2.4	1.1	-	1.6	1.9	3.5	.3	1.1	.6	.4	.4	.6	-	.2	.5	1.0
1600	.7	.6	.5	.5	1.1	.3	1.5	2.2	2.3	1.3	.2	1.5	1.4	4.1	.7	.6	.7	.3	.4	.7	-	.2	.8	1.0
1700	1.2	.3	.8	.7	.6	.3	1.0	2.0	1.6	.8	.2	.9	-	3.1	1.0	.3	.8	.3	.4	.8	-	.2	.8	.8
1800	1.5	.4	.5	.7	.5	.3	.6	2.1	.9	.5	.2	.6	-	2.4	1.0	.5	.6	.3	.3	.7	.7	.2	.7	.8
1900	1.5	.6	.7	.6	.4	.3	.7	2.1	.8	-	.2	.7	.8	2.3	.7	.5	.4	.3	.2	.8	.6	.2	.6	.7
2000	.9	.7	.4	.5	.4	-	.6	1.4	.8	-	.4	.6	.6	1.6	.7	.5	.3	.4	.2	.8	.7	.2	.6	.7
2100	1.1	.4	.4	.8	.5	.4	.6	1.1	.9	-	.5	.6	.8	1.6	.9	.5	.3	.3	.1	.8	.7	.3	.4	.7
2200	-	.3	.3	.6	.5	.5	.5	.7	.7	-	.4	.5	.7	1.2	.9	.4	.3	.3	.2	.6	.5	.3	.3	.3
2300	.8	.3	.3	.6	.4	.3	.4	.7	1.0	-	.3	.6	.6	.3	.6	.4	.3	.2	.1	.6	.4	.3	.2	.2
2400	.5	.4	.2	.9	.4	.3	.5	.6	.9	-	.2	.6	.3	.1	.4	.3	.3	.3	.1	.5	.4	.3	.1	.2

* Less than 0.1 ppb

The corresponding concentration in Atlanta is less than 1.0 ppb.

On a daily basis there existed a good correlation between PAN and ozone. Figure 5 shows that little or no PAN production was observed on days when ambient ozone levels remained below 80 ppb. Since PAN is considered to be a tracer of urban photochemical pollution, the excellent correlation between PAN and ozone supports the contention that high ozone levels during the study in Atlanta resulted from anthropogenic causes rather than subsidence from aloft. Ozone/PAN ratios derived from the data shown in Figure 5 vary from about 30:1 to near 100:1. These are fairly typical of the ratios observed at urban and suburban sites in the midwestern and eastern U.S. but are greater than the ratios generally recorded in the Los Angeles area (7). During periods of peak ozone in the Los Angeles basin, the ozone/PAN ratio ranged between 8:1 and 25:1.

OXIDANT PRODUCTION AND TRANSPORT

In order to characterize ozone production in the Atlanta area, a detailed discussion of the air chemistry observed on two separate days will be provided. Ozone behavior on July 17 is typical of that observed on days with fairly constant winds out of the northwest quadrant. Ozone patterns characteristic of low ventilation conditions are exemplified by conditions on July 24. One or the other of these two scenarios existed when high ozone levels were recorded within or downwind of Atlanta.

July 17, 1981

Weather patterns around July 17 were influenced by a high pressure system located over the Gulf of Mexico (see Figure 2). Gradient wind flow around the

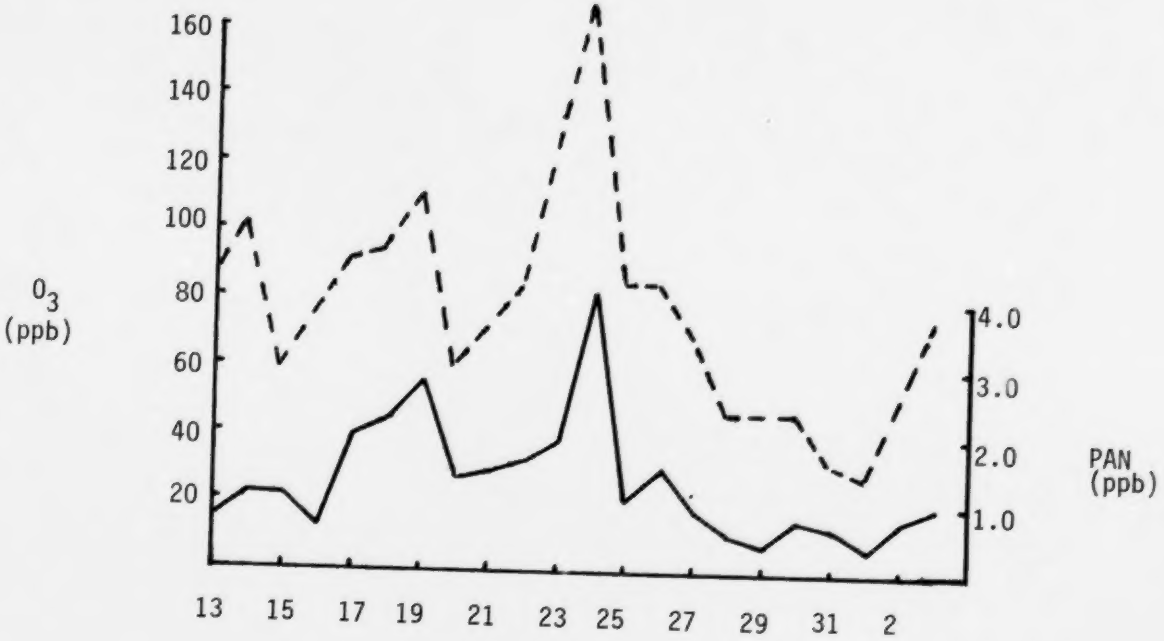


Figure 5. Maximum hourly average PAN (——) and O_3 (---) concentrations recorded at the Georgia Tech site.

high resulted in transport of air masses into the Atlanta area which originated in the Gulf Coast area and passed over portions of Texas, Louisiana, Mississippi and Alabama. Winds were out of the northwest from the surface to 6000 ft throughout the day on July 17. Table 12 lists Atlanta wind information for the period between 8:00 a.m. and 6:00 p.m.

The percentage of daily available sunshine measured at Georgia Tech corresponded to 64% on July 17 which was about the norm for Atlanta during July, 1981. With afternoon temperatures above 90°F, conditions were conducive for oxidant formation and the constant northwesterly wind flow made it relatively easy to predict the location of the oxidant plume emanating from Atlanta. Ozone levels in excess of 150 ppb were observed downwind of Atlanta in the afternoon hours on July 17.

Figure 6 shows the morning flight path with ozone concentrations marked at specific points along the route. The flight began at 8:05 a.m. with departure from the DeKalb-Peachtree airport. Following a spiral ascent and descent northeast of the airport, the aircraft flew a counterclockwise circle around Atlanta at altitudes varying between 1500 and 2500 ft above the surface. Ozone concentrations to the west (upwind) of Atlanta were in the 75-85 ppb range while ozone levels east of Atlanta in the downwind sector were generally in the 60-70 ppb range. The Atlanta plume was clearly evident in the region between the 130 and 110 degree radials as shown in Figure 7. Ozone levels were reduced to the 20 ppb range and elevated b_{scat} concentrations were recorded. Depressed O_3 is the result of reaction with fresh emissions in the Atlanta area. After completing the counterclockwise arc around Atlanta the airplane passed directly over the city in the north to south direction and then returned to the DeKalb-Peachtree airport (Figure 6). Ozone levels were depressed directly over Atlanta

TABLE 12. METEOROLOGICAL DATA RECORDED ON JULY 17, 1981[a]

SURFACE RECORDINGS

Time (EDT)	WS (mph)	WD (deg.)	TEMP (°C)	RAD (Ly)
0800	-	-	-	-
0900	-	-	-	-
1000	-	-	-	-
1100	7	283	28.5	0.9
1200	6	285	29.5	1.0
1300	5	291	30.6	1.2
1400	5	290	31.2	0.9
1500	6	293	31.9	0.9
1600	6	271	32.5	0.9
1700	6	256	32.9	0.8
1800	5	297	32.6	0.5

WINDS ALOFT

Alt (ft)	0900	1100	1400	1600
500	9/334[b]	3/314	9/306	7/312
1000	15/320	4/333	11/300	10/309
1500	14/307	5/326	11/294	10/310
2000	14/308	8/320	10/310	10/314
2500	11/314	8/315	8/296	9/310
3000	13/315	10/325	14/307	9/290
3500	14/319	13/322	11/312	8/289
4000	20/316	14/317	7/306	8/277
4500	20/311	20/311	5/290	5/300
5000	21/304	22/307	9/342	10/319

[a] All measurements at DeKalb-Peachtree site

[b] WS (mph)/WD (deg.)

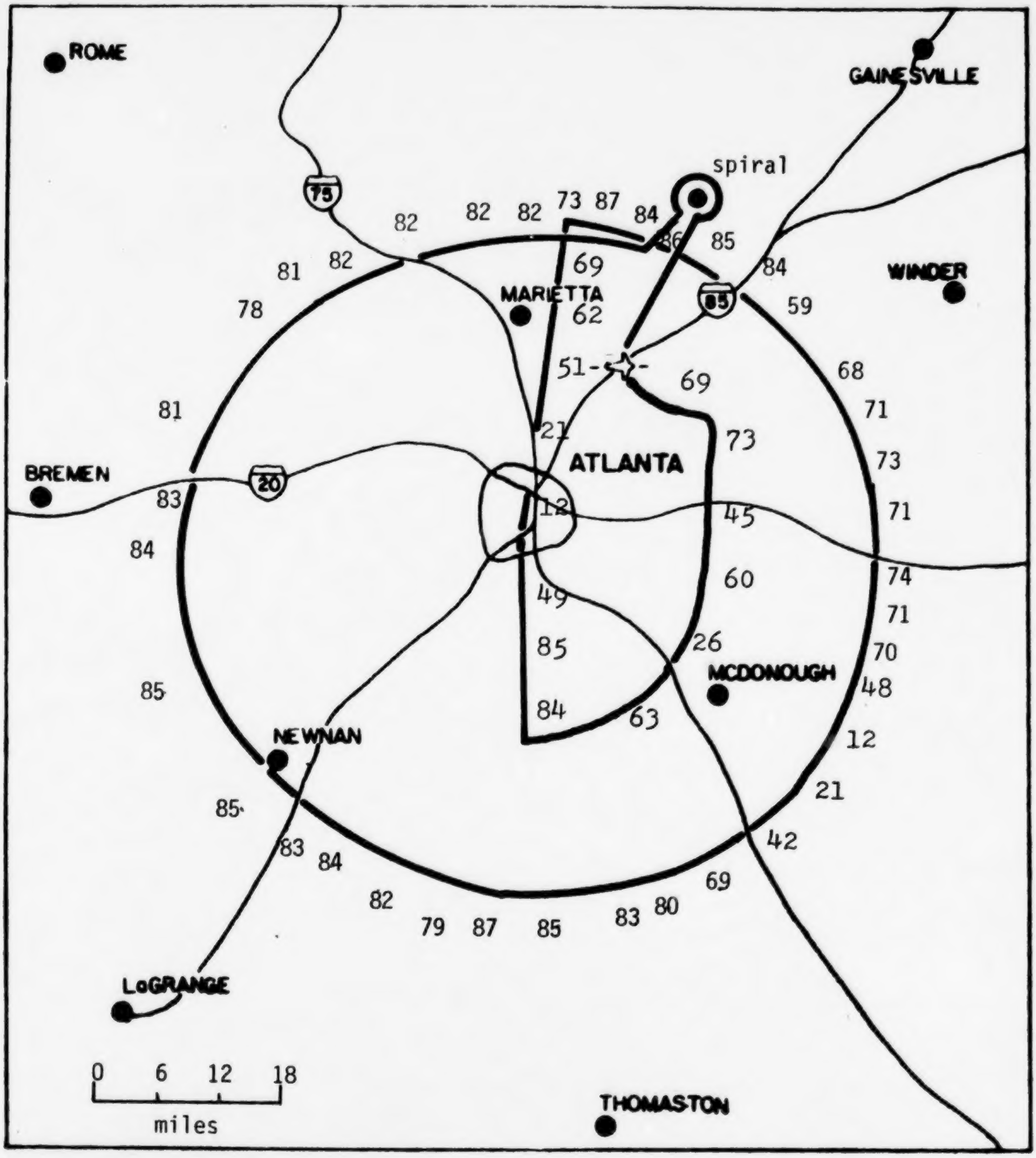


Figure 6. July 17, 1981, morning (8:05 - 10:18 a.m.) flight path with ozone concentrations (ppb) marked along the route. Altitude of the flight ranged between 1500 - 2500 ft.

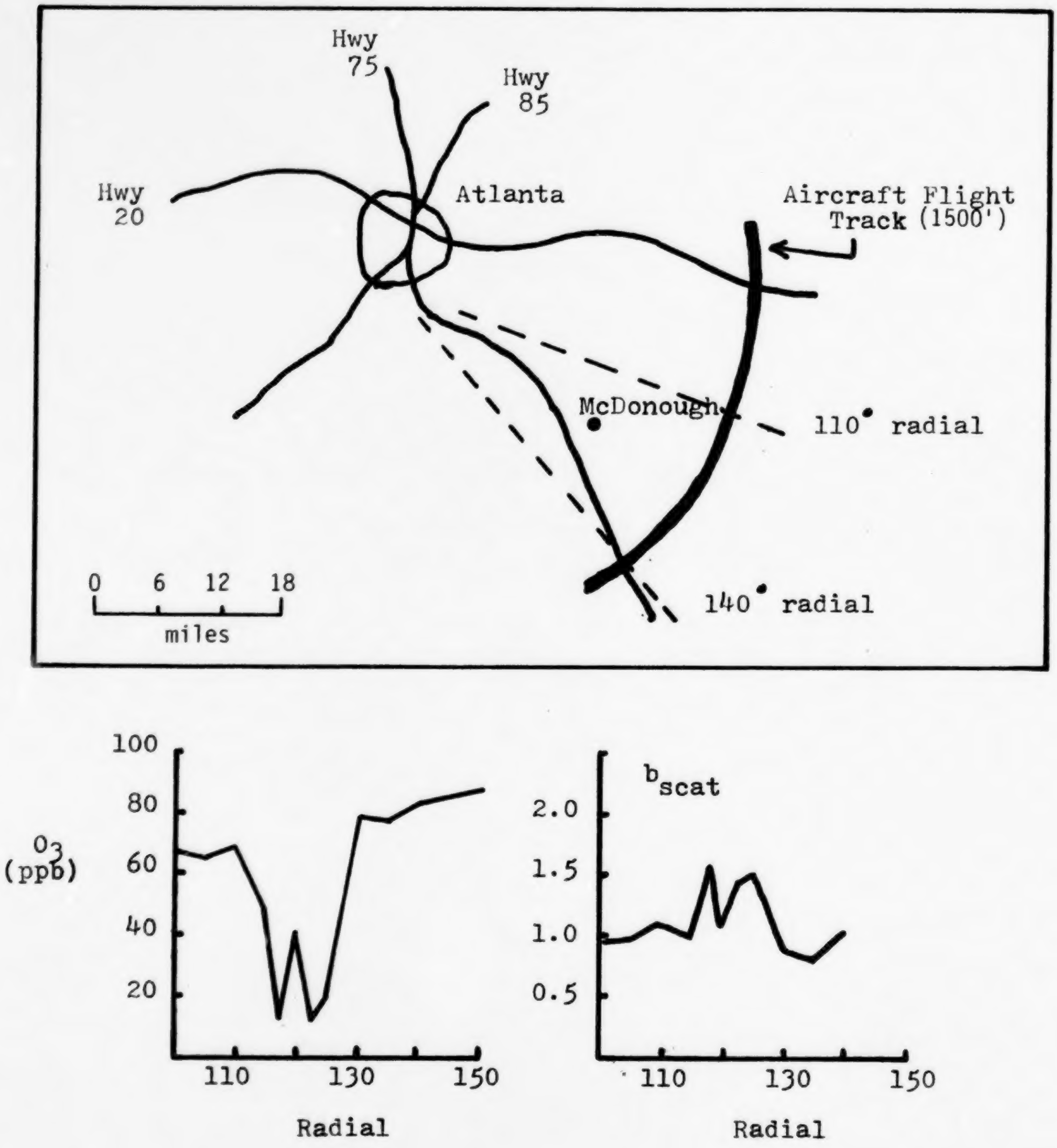


Figure 7. Ozone and b_{scat} measured with the aircraft southeast of Atlanta during morning hours on July 17, 1981.

at 1500 ft and also southeast of Atlanta along the return leg to the airport.

It is clear from the foregoing discussion that ozone levels were in the 20-40 ppb range over and downwind of Atlanta during the early morning hours on July 17. In contrast, air moving into the Atlanta region from the northeast exhibited ozone concentrations in the 75-85 ppb range.

The aircraft sounding near the beginning of the morning flight was useful for establishing vertical pollutant profiles. Ozone and temperature changes with altitude at 8:30 a.m. are shown in Figure 8. The ozone profile shows values in the 65-75 ppb range at altitudes above 1000 ft. The temperature and ozone profiles indicate the presence of an inversion below about 1000 ft. The ozone concentration was depressed by more than 15 ppb at 500 ft compared to levels above the morning inversion.

Ozone concentrations recorded at surface stations around the Atlanta area during the afternoon hours on July 17 are listed in Table 13. Highest concentrations were measured at the DeKalb CC and Conyers sites which were on the downwind side of Atlanta. The DeKalb-Peachtree and Georgia Tech ozone maxima of 93 ppb were intermediate between the values recorded at the upwind station (Dallas) and those observed at the two downwind sites.

TABLE 13. HOURLY AVERAGE SURFACE OZONE CONCENTRATIONS (ppb) ON JULY 17.

Time	Dallas	DeKalb-Peachtree	Georgia Tech	DeKalb CC	Conyers
1200	55	71	46	55	-
1300	55	74	59	70	-
1400	55	78	-	90	-
1500	60	70	-	95	125
1600	60	75	-	100	120
1700	65	93	93	110	125
1800	55	82	84	105	130

Data obtained during the afternoon flight on July 17 were very useful for defining the impact of Atlanta area emissions on the downwind region.

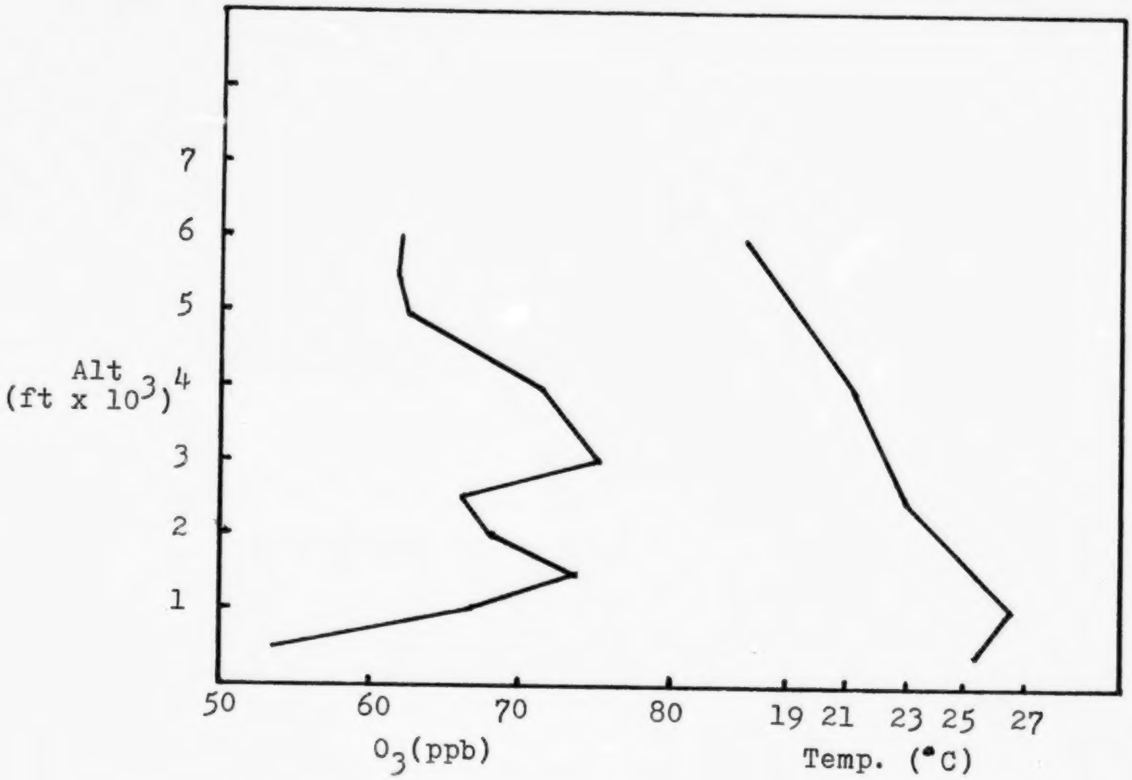


Figure 8. Ozone and temperature changes with altitude recorded at 8:15 AM on July 17, 1981.

Figure 9 shows the path flown and ozone concentrations at various points along the route. The flight began at DeKalb-Peachtree airport and after a vertical sounding northeast of Atlanta consisted primarily of a series of traverses across the Atlanta plume at various downwind distances. The aircraft did make one complete circle around Atlanta in order to define ozone levels in incoming air during the afternoon hours. Ozone and temperature changes with altitude at 1:00 p.m. are plotted in Figure 10. Ozone concentrations decreased from about 70 ppb at 500 ft to 60 ppb at 4000 ft. Between 4000 and 5000 ft the ozone concentration increased rapidly from about 60 to 70 ppb. This upper level ozone increase undoubtedly marked the mixing level during the early afternoon hours. This is supported by the temperature profile which shows a steady decrease in temperature with altitude from near the surface to 4000 ft. Between 4250 and 4750 ft the temperature increases slightly with altitude indicating an inversion condition which typically signifies the mixing limit.

Ozone levels at 2500 ft along the arc upwind of Atlanta ranged between about 60 and 90 ppb (see Figure 9). The 90 ppb concentrations were recorded in two relatively narrow bands centered around the 330° and 290° radials. Along the remainder of the upwind circle ozone concentrations were near 60-70 ppb.

The dashed lines in Figure 11 beginning at the northern and southern fringes of Atlanta and extending to the southeast mark the boundaries of the Atlanta plume on the afternoon of July 17. Crosswind ozone profiles recorded along the 35 and 45 mile downwind arcs at 2500 ft are shown in Figure 12. At 35 miles downwind, a broad ozone plume was observed at 2500 ft extending from south of McDonough to the region east of Stone Mountain. This corresponds to a plume width of about 40 miles. The maximum ozone concentration recorded at

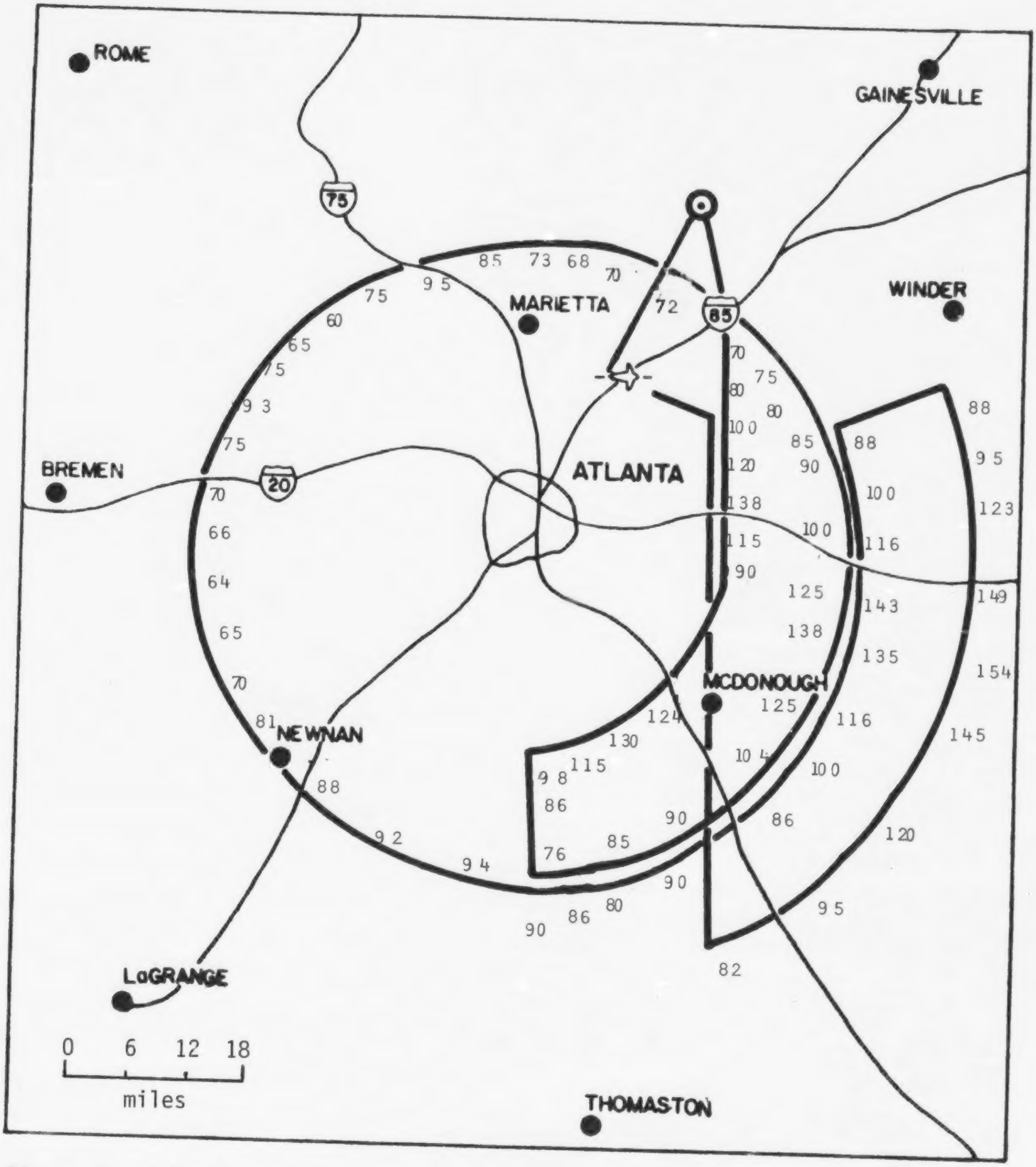


Figure 9. July 17 afternoon (12:42 - 15:48 p.m.) flight path with ozone concentrations (ppb) marked along the route.

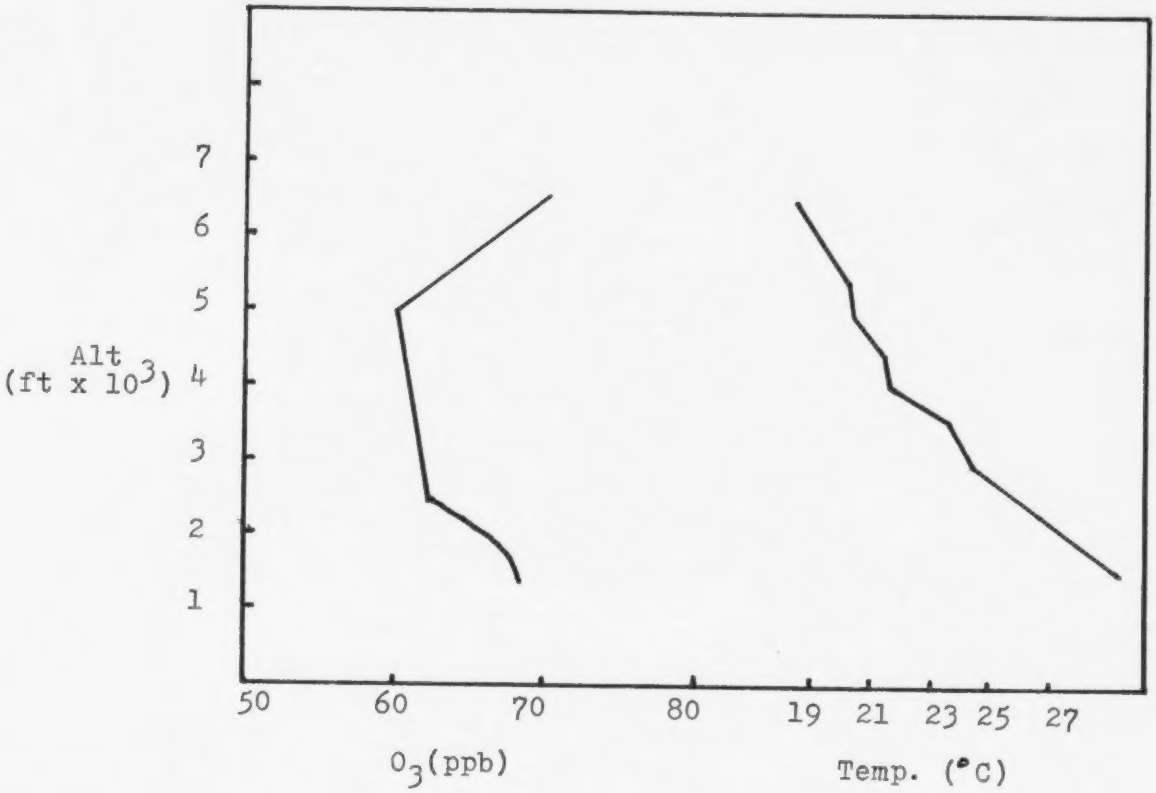


Figure 10. Ozone and temperature changes with altitude recorded at 1:00 pm on July 17, 1981.

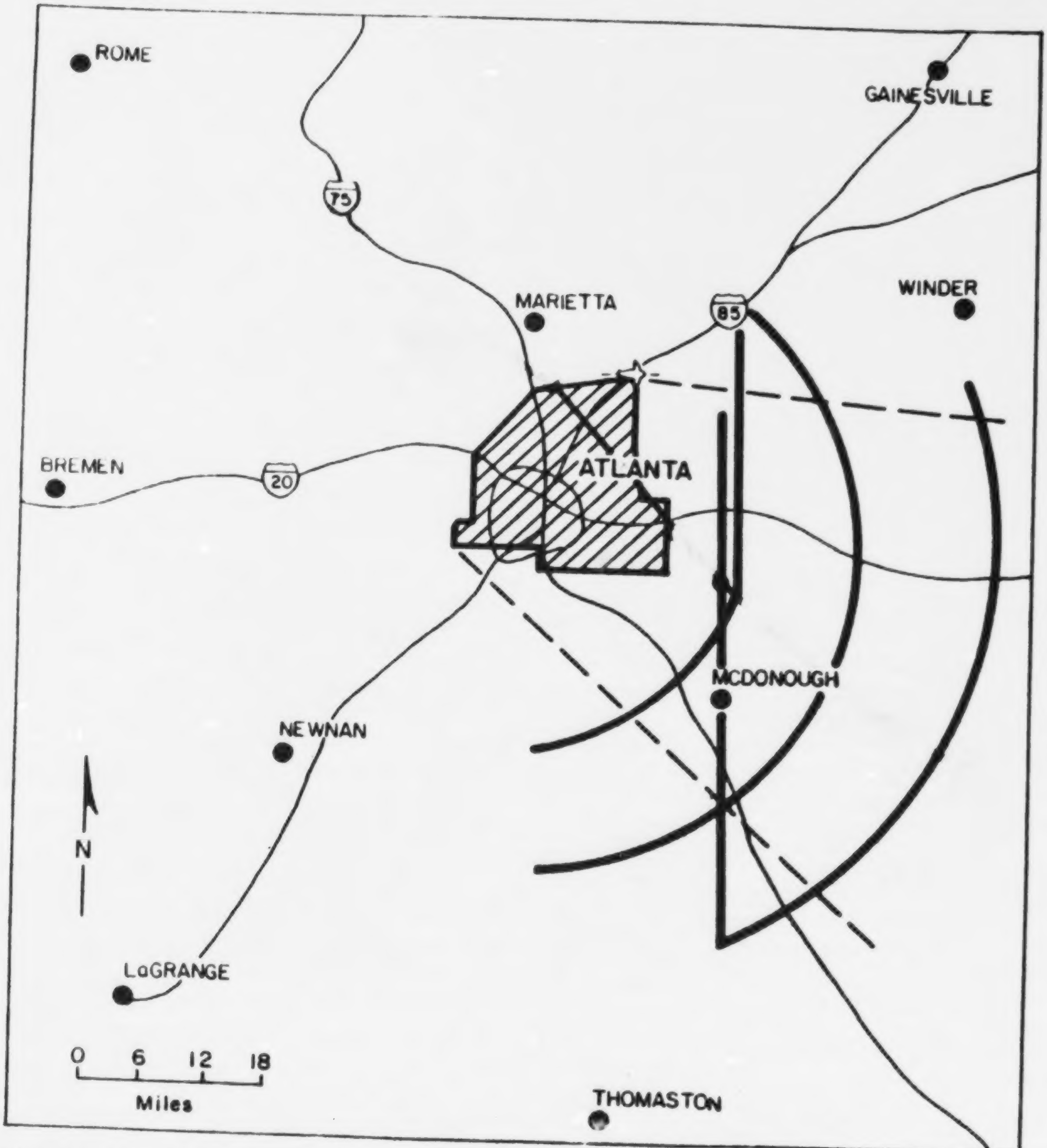


Figure 11. Aircraft traverses (solid lines) across the Atlanta plume (dashed lines) on the afternoon of July 17, 1981.

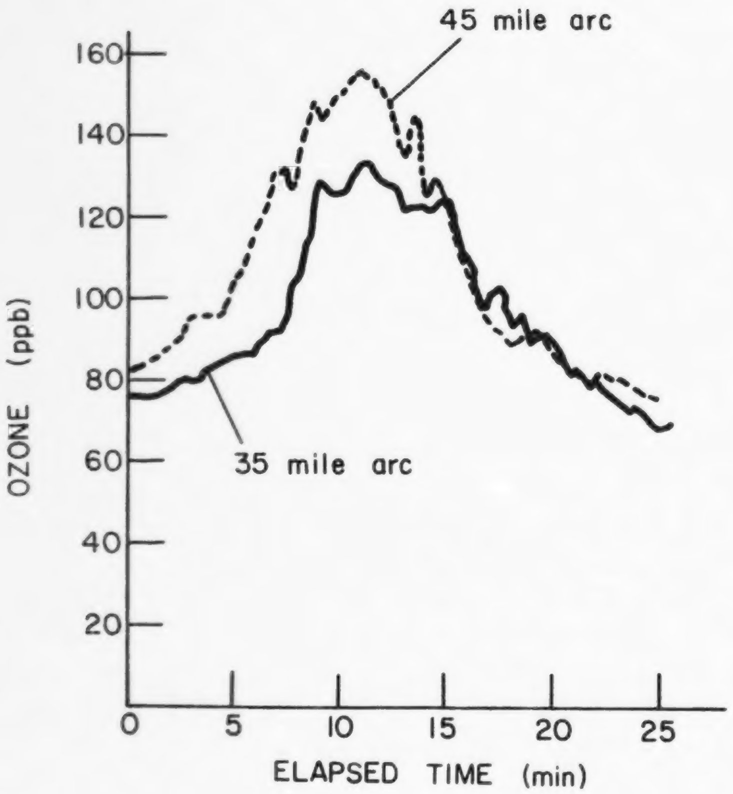


Figure 12. Crosswind ozone profiles recorded in the Atlanta plume at 2500 feet on July 17.

this distance was 137 ppb. A back trajectory analysis based on winds within the mixed layer indicated that the air parcel sampled at 35 miles had passed over the Atlanta urban area between 9 and 10 a.m. This same air mass was monitored at a distance of 45 miles downwind 1½ hours later in the day. As can be seen in Figure 12, the peak ozone concentration had increased by about 20 ppb to 158 ppb along the 45 mile arc. At this distance, elevated ozone concentrations were measured over a crossplume distance of about 50 miles. Background concentrations to the north and south of the plume were approximately 90 ppb. Thus, the ozone buildup along the centerline of the Atlanta plume on July 17 corresponded to about 70 ppb.

Vertical ozone structure within the plume cannot be clearly defined on this day due to a lack of plume traverse data at various altitudes. However, based on data collected on other afternoons with similar meteorological conditions, peak ozone levels remain fairly constant with altitude along the plume centerline from near the surface to the top of the mixed layer. Thus, on July 17 it can be assumed that ozone concentrations 45 miles southeast of Atlanta were in the 150-160 ppb range from the surface to about 4000 ft.

This flight data, collected on July 17, clearly shows a pronounced ozone plume as far as 45 miles downwind of Atlanta. Ozone concentrations approached 160 ppb at that distance and remained elevated over a cross-sectional distance of about 50 miles. It is likely that elevated ozone levels within the plume extended from the surface to 4000 ft.

July 24, 1981

As indicated previously, wind conditions on July 24 differed from most other days during the study period. A stationary front was positioned over the Atlanta area which resulted in low ventilation conditions. As shown in Table 14, wind speeds between the surface and 6000 ft were less than 10 mph during the daylight hours. At 9:15 a.m. the wind direction varied considerably with altitude. From the surface to about 1200 ft, winds were out of the east at approximately 6 mph. In the zone between 1500 ft and 3500 ft, the wind direction changed from easterly to westerly. Above 3500 ft, wind flow was from the northwest quadrant.

The 11:00 a.m. pibal showed upper level wind patterns essentially the same as that described at 9:15 a.m. A change in wind direction at altitudes below 1200 ft is evident during the afternoon hours. While the two morning pibals had shown wind from the surface to 1200 ft to be from the east, data recorded during the 2:00 p.m. pibal indicated a northwesterly flow in this surface layer. It should be noted, however, that wind speeds in this surface layer were very low, generally less than 3 mph. Due to the complex vertical wind structure and low wind speeds on July 24, it is difficult to plot air mass trajectories with any degree of accuracy. It would appear, however, that surface emissions in the Atlanta urban area drifted slowly to the west during the morning hours and then reversed direction and were carried back into the urban region during the afternoon hours.

Cloud cover was minimal between sunrise and sunset on July 24. Afternoon temperatures reached 34°C at the DeKalb-Peachtree monitoring site. Thus, due to ample sunlight, warm temperatures and stagnant wind conditions, data collected on July 24 can be used to characterize near optimum ozone production conditions in the Atlanta region.

The morning vertical ozone profile recorded by the aircraft at 8:30 a.m. showed considerable variation with altitude. As can be seen in Figure 13,

TABLE 14. METEOROLOGICAL DATA RECORDED ON JULY 24, 1981[a]

SURFACE RECORDINGS

Time (EDT)	WS (mph)	WD (deg.)	TEMP (°C)	RAD (Ly)
0800	4	077	23	0.1
0900	6	081	24	0.3
1000	5	091	25	0.6
1100	4	083	27	0.9
1200	2	105	29	1.1
1300	3	050	30	1.1
1400	4	155	32	1.3
1500	4	356	33	1.2
1600	4	256	34	1.0
1700	3	291	34	0.7
1800	4	261	34	0.4

WINDS ALOFT

Alt (ft)	0915	1100	1400
500	5/109[b]	4/082	1/300
1000	8/125	5/106	2/360
1500	6/155	5/182	3/110
2000	6/148	8/199	3/155
2500	8/180	7/217	2/225
3000	6/200	6/250	1/250
3500	5/254	6/277	4/197
4000	8/290	8/321	5/288
4500	9/295	7/315	-
5000	7/325	5/286	-

[a] All measurements at DeKalb-Peachtree site
[b] WS (mph)/WD (deg.)

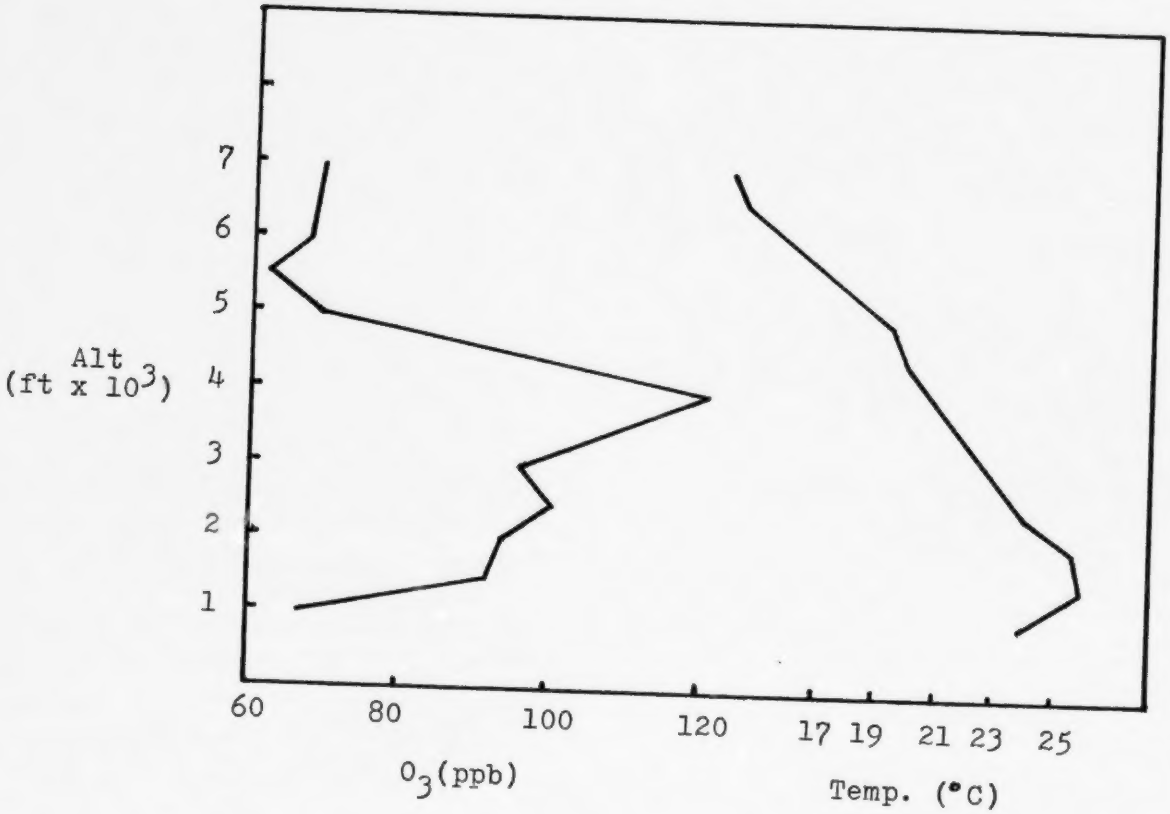


Figure 13. Ozone and temperature changes with altitude recorded at 8:30 am on July 24, 1981.

ozone levels were below 70 ppb from the surface to approximately 1250 ft; fairly constant in the 95-100 ppb range in the zone from 1500-3000 ft; somewhat higher (110-120 ppb) in a narrow band between 3500-4000 ft; and then back down to the 60 ppb range above 4500 ft. The vertical temperature profile, which is also shown in Figure 13, clearly indicates the presence of a surface inversion below 1500 ft. Low ozone levels are typically observed below a surface inversion during the morning hours. It is difficult to determine whether the two bands of elevated ozone at 1500-3000 ft and 3500-4000 ft are part of the same air mass or originated in two different source regions. The temperature profile shows a slight, but definite, discontinuity between the two layers of elevated ozone. Also, wind directions in the two layers were from opposite directions (1500-3000 ft, southeast; 3500-4000 ft. northwest). These meteorological factors suggest the existence of separate air masses and perhaps different ozone sources.

As the day progressed, the surface inversion dissipated and ozone concentrations increased in the region below 1500 ft. However, the distinct layers at higher altitudes remained intact. A vertical aircraft sounding north of Atlanta at 1:00 p.m. showed ozone levels of about 100 ppb from the surface to 3000 ft (Figure 14). This implies that convective mixing due to surface heating existed up to an altitude of 3000 ft. The layer with elevated ozone concentration that had been observed between 3500 and 4000 ft earlier in the day was still present and, in fact, at 1:00 p.m. exhibited levels as high as 150 ppb. As during the morning hours, ozone concentrations above 4500 ft were less than 70 ppb.

These findings indicate that oxidant precursors emitted in the Atlanta urban area on July 24 remained in a shallow mixing zone between the surface and 3000 ft. Due to the low mixing height and light and variable winds, dilution

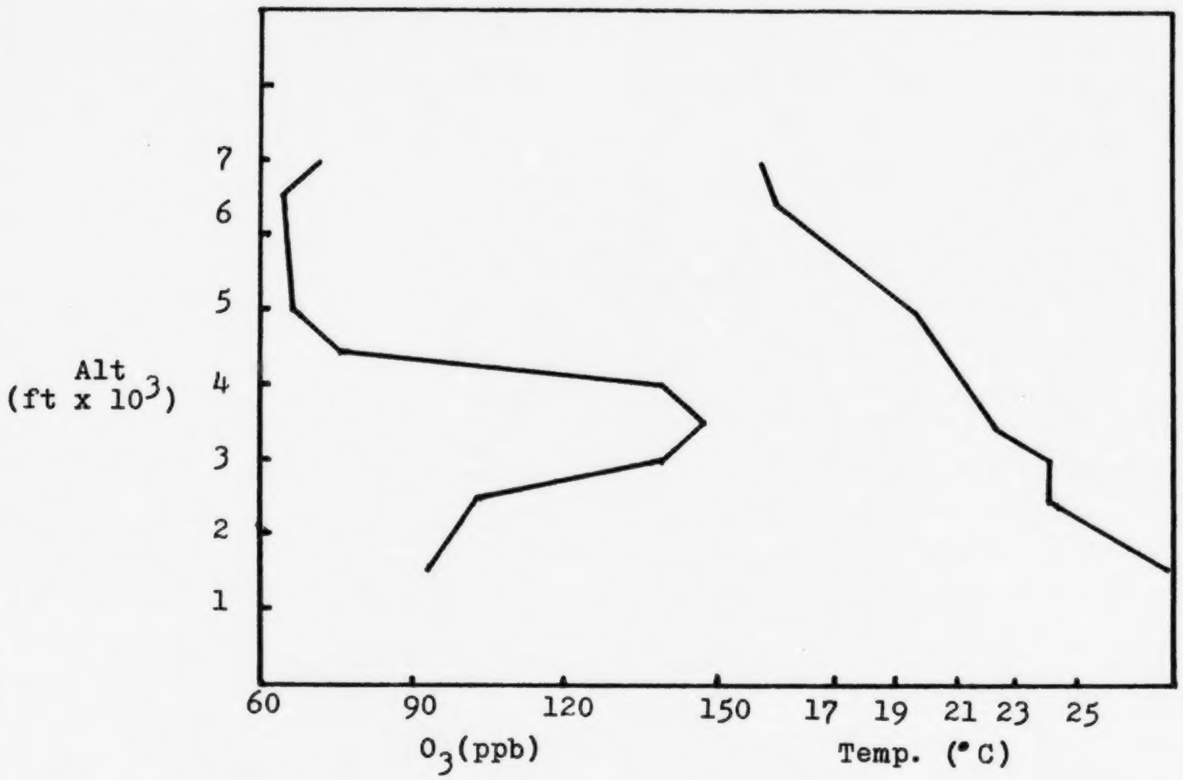


Figure 14. Ozone and temperature changes with altitude recorded at 1:00 p.m. on July 24, 1981. (See Figure E15 for spiral location.)

was minimal. Consequently, high ozone concentrations were recorded throughout the Atlanta area. A 30-mile aircraft circle around Atlanta at 1500 ft during the mid-afternoon hours showed ozone concentrations between 100 and 160 ppb in nearly all sectors. The highest concentrations recorded aloft were approximately 190 ppb at 4:30 p.m. near the DeKalb-Peachtree airport. The high ozone concentrations were observed in the surface layer at altitudes below 1500 ft.

Surface ozone concentrations measured on July 24 at the three Atlanta urban/suburban sites were the highest recorded during the study period. Table 15 lists hourly average ozone concentrations recorded at all Atlanta area surface monitoring stations on July 24. The peak values exceeded 165 ppb at Georgia Tech and DeKalb-Peachtree during the late afternoon hours. The DeKalb CC high value was 145 ppb at 5:00 p.m. while the Conyers maximum hourly average concentration was 120 ppb at 5:00 p.m. The late peak at Conyers is not unexpected based on the wind pattern previously discussed. The shift to westerly flow about noon coupled with relatively low wind speeds contributed to the late arrival of the urban air mass at Conyers.

TABLE 15. HOURLY AVERAGE SURFACE OZONE CONCENTRATIONS (ppb) ON JULY 24.

Time	Dallas	DeKalb-Peachtree	Georgia Tech	DeKalb CC	Conyers
0900	10	17	14	25	35
1000	35	40	39	-	45
1100	40	57	53	55	50
1200	65	76	71	65	60
1300	95	99	106	70	75
1400	95	126	147	85	90
1500	90	134	154	95	100
1600	80	159	168	115	100
1700	80	172	167	145	95
1800	75	163	130	135	95
1900	60	146	126	125	105
2000	35	119	122	70	120
2100	5	92	96	50	85
2200	25	30	32	20	60

Figure 15 shows the diurnal changes of various pollutants associated with the photochemical oxidation cycle. These data were recorded at the Georgia Tech monitoring site on July 24. The diurnal pollutant patterns shown in Figure 15 are consistent with a photochemical oxidant production mechanism. Following an oxides of nitrogen peak between 7:00 and 9:00 a.m., ozone levels increased rapidly reaching a peak hourly average at 4:00 p.m. EDT. PAN production correlated closely with ozone formation. The maximum hourly average PAN concentration (4.1 ppb) was recorded at 4:00 p.m. coincident with the ozone peak. The presence of PAN implies a photochemical source of oxidants.

Hydrocarbon data collected during the 6-9 a.m. period at Georgia Tech on July 24 are summarized in Table 16. The 6-9 a.m. average of 342 ppbC is below the 491 ppbC mean for the overall study period. Data in Table 16 indicate a hydrocarbon mix very rich in olefinic species on the morning of July 24. However, this should be viewed with caution because much of the olefinic contribution was from ethylene. It is extremely difficult to eliminate ethylene contamination when hydrocarbon samples are collected in close proximity to a chemiluminescent ozone monitor. A 6-9 a.m. average oxides of nitrogen concentration of 33 ppb was recorded at the Georgia Tech site on July 24 which when

TABLE 16. HYDROCARBON DATA COLLECTED AT THE GEORGIA TECH SITE ON JULY 24, 1981

	6-7 a.m.		7-8 a.m.		8-9 a.m.		6-9 a.m.	
	ppbC	%	ppbC	%	ppbC	%	ppbC	%
NMHC	338	-	312	-	377	-	342	-
Paraffins	146	51	143	54	153	48	147	51
Aromatic	72	25	71	27	100	32	81	28
Olefin	68	24	50	19	64	20	61	21

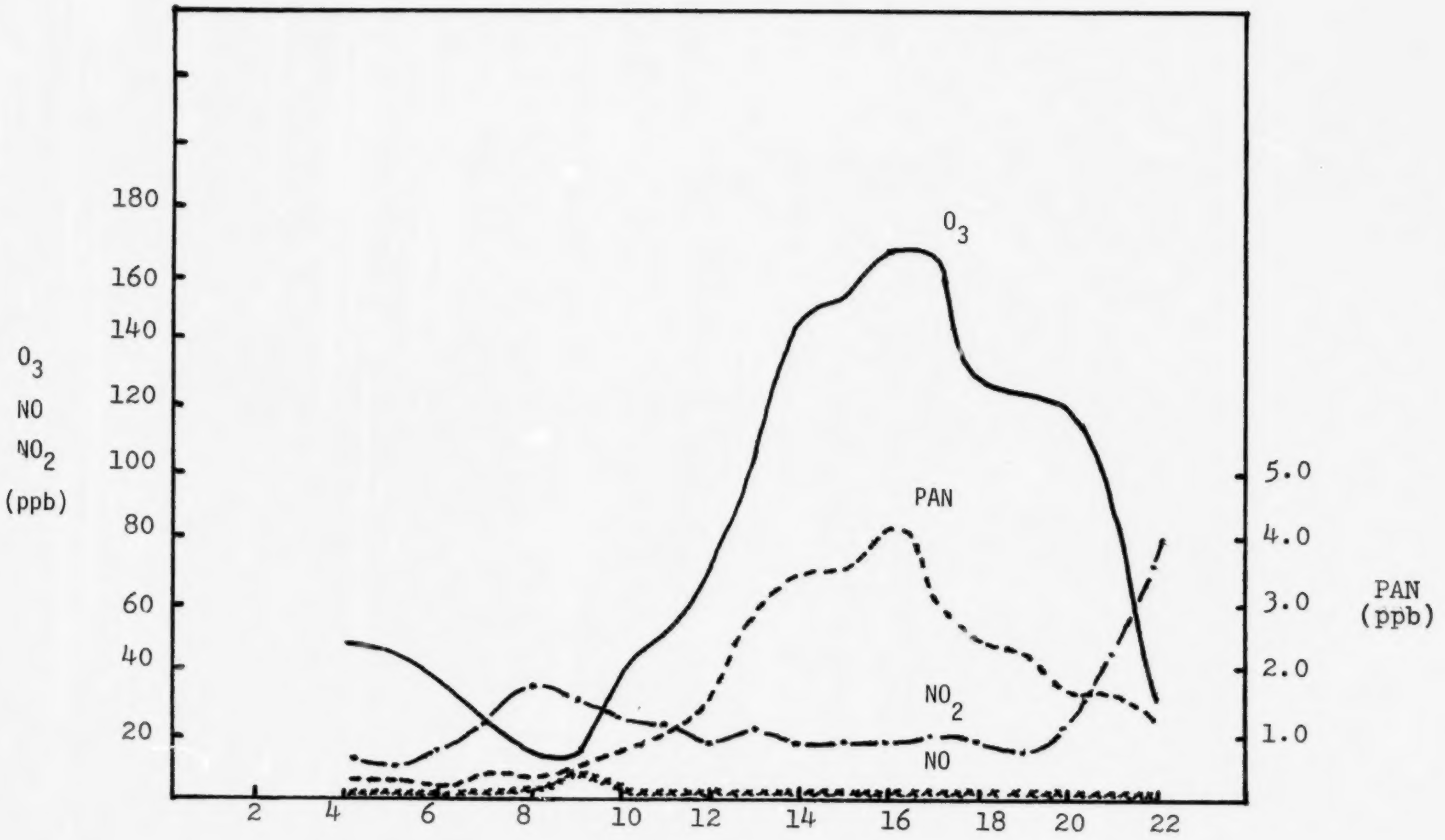


Figure 15. Pollutant changes at the Georgia Tech site on July 24, 1981.

combined with the hydrocarbon total yields a HC/NO_x ratio equal to 10.4. Even if this ratio is slightly high due to the ethylene problems mentioned previously, it is within the range acceptable for photochemical oxidant production. Another indication of photochemical activity is a decrease in the percentage of reactive olefins as the day progresses. As shown in Table 17, all sampling stations showed a lower olefinic content during the afternoon hours on July 24.

TABLE 17. MORNING AND AFTERNOON HYDROCARBON SPECIES DISTRIBUTIONS IN ATLANTA ON JULY 24, 1981

	Georgia Tech	Fulton Co. Health Dept.	DeKalb CC	DeKalb-Peachtree
MORNING (6-9 a.m.)				
% Paraffin	51	55	56	74
% Aromatic	28	28	30	14
% Olefin	21	17	14	10
AFTERNOON (11 a.m.-2 p.m.)				
% Paraffin	63	59	57	75
% Aromatic	36	30	34	14
% Olefin	11	12	9	9

EKMA MODELING

The Empirical Kinetic Modeling Approach (EKMA) is designed for regulatory application to oxidant control problems. In the city specific mode, the model (OZIPP) treats a well-mixed air parcel advected along some arbitrary trajectory (8). The volume of the parcel grows as a function of the growth of the mixed layer, and the photochemistry in the parcel proceeds as a function of the time of day. Because of the widespread use of EKMA, it is of interest to compare ozone concentrations predicted by the city specific version (OZIPP) with observed ozone concentrations such as were collected in the Atlanta study.

Model input parameters for OZIPP include the initial and final mixing heights and times, the initial nonmethane hydrocarbon (HC) and NO_x concentrations, a hydrocarbon reactivity factor expressed as a fractional distribution of butane, propylene and aldehyde species, and the NO_2/NO ratio. The concentrations of ozone, hydrocarbons, and NO_x in the incoming air aloft and at the surface are also required. Temperature and pollutant data recorded during early morning and early afternoon aircraft spirals were combined with NWS radiosonde data from Athens, GA, to establish the necessary mixing heights. Initial HC and NO_x concentrations and the NO_2/NO_x ratio were taken from 6-9 a.m. measured at the two surface stations in downtown Atlanta (Georgia Tech and Fulton County Health Dept.). Concentrations aloft and at the surface in incoming air were determined from early morning aircraft spirals and traverses along the upwind boundary. Default values of 0.25 and 0.05 were assigned to the initial propylene and aldehyde fractions. The model was run from 8 a.m. to 6 p.m. Post-8 a.m. emissions were not included due to uncertainties in their spatial distribution in and around Atlanta.

We will present and discuss model results for three days during the study period. Two of the days, July 17 and July 24, were described in detail earlier. It should be recalled that air parcels over Atlanta during the 6-9 a.m. period on July 17 were transported to the southeast by steady winds out of the northwest. On July 24 low ventilation conditions persisted throughout the daylight hours and, consequently, the morning air parcels remained in the immediate urban area during the daytime period. July 15 was the third day utilized in this modeling exercise. Steady winds from the northwest resulted in a well defined urban plume southeast of Atlanta on July 15 similar to that observed on July 17.

Input data and predicted maximum ozone concentrations for July 15, 17 and 24 are listed in Table 18. The input parameters shown in Table 18 were determined from aircraft or surface measurements whenever possible. For example, mixing height data and ozone levels aloft were acquired from airborne measurements while surface O_3, initial HC, initial NO_x and NO_2/NO_x were obtained from ground level records. Concentrations assigned to the remaining parameters required for initializing the model (HC surface, NO_x surface, HC aloft and NO_x aloft) were based on our best estimate of hydrocarbon and NO_x levels typically observed in background air masses. Maximum predicted ozone concentrations varied from 133 ppb on the 15th to 153 ppb on the 24th. In all three cases, the maximum concentrations were predicted to occur at approximately 4:00 p.m. EDT. For comparative purposes, Table 18 also lists the maximum ozone concentrations measured along crosswind aircraft traverses during afternoon hours on July 15, and 17 and the maximum observed hourly average concentration at Atlanta area surface stations on July 24. Without regard to specific air mass trajectories, the comparison between predicted and observed concentrations shows slight model underprediction on each day.

A thorough evaluation of OZIPP based upon a comparison of predicted and observed ozone concentrations requires consideration of the actual air mass trajectories during the day. As part of the study, Pilot balloon (pibal) observations were made at the DeKalb-Peachtree airport four times daily beginning at 9:00 a.m. Hourly averaged wind data from a 50 m tower operated by the Geophysical Sciences Department at Georgia Tech were also available.

TABLE 18. SUMMARY OF OZIPP MODELING RESULTS

Model Input	Date 7/15	7/17	7/24
Initial Mixing Height (ft. - agl)	1500	1500	1500
Final Mixing Height (ft. - agl)	4500	4500	3000
Time Final Height	1600	1300	1100
NO_2/NO_x	0.80	0.57	0.74
O_3 Surface (ppb)	8	20	13
HC Surface (ppbC)	50	50	50
NO_x Surface (ppb)	15	15	15
O_3 Aloft (ppb)	65	80	100
HC Aloft (ppbC)	20	20	20
NO_x Aloft (ppb)	5	5	5
Initial HC (ppbC)	420	495	525
Initial NO_x (ppb)	79	69	34
Maximum O_3 Predicted (a)	133	142	153
Observed O_3 Maximum	135(b)	158(b)	161(c)

(a) O_3 maximum predicted at 3:00 pm.

(b) Aircraft measurement at 3:00 pm in air mass that passed over Atlanta during morning hours (6-9 am).

(c) Hourly average maximum O_3 observed at the Georgia Tech, DeKalb CC and Peachtree-DeKalb sites.

These data provide a basis for calculating forward or backward air parcel trajectories on the days of interest. These calculations were completed for July 15, 17 and 24 using a linear interpolation scheme where the surface data were used to define the wind vectors prior to the first pibal reading (9). Speed and direction data from the pibal releases were vector averaged from the surface up to the mixing height which was defined by linear interpolation between the initial and final mixing heights and times. This approach yields trajectories based upon surface data during the early morning (when the HC and NO_x emissions are within a low-mixed layer) and based upon the average wind within the mixed layer during the remainder of the day.

As described in a later section, this scheme was tested by comparing the predicted air mass trajectory on several days with detailed SF_6 tracer data obtained following a 6-9 a.m. surface tracer release from the Georgia Tech site. Both the path and the plume transport times predicted from the wind data agreed well with the tracer observations. The close agreement indicates that the simple trajectory scheme worked quite well in the flat terrain surrounding Atlanta.

Application of the wind analysis to July 17 yields trajectories that travel directly southeast of the city with very little curvature for start times from 8:00 a.m. to noon. A back trajectory starting at the position where the maximum O_3 concentrations were observed during the afternoon hours is shown in Figure 16. The trajectory indicates that the aircraft traversed air masses which passed directly over or slightly north of the Atlanta urban center at times beginning after 8:00 a.m. In particular, the maximum ozone concentration (158 ppb) observed during the flight was at a point 45 miles downwind in air that passed through the Atlanta area beginnning at 9:00 a.m. In this case,

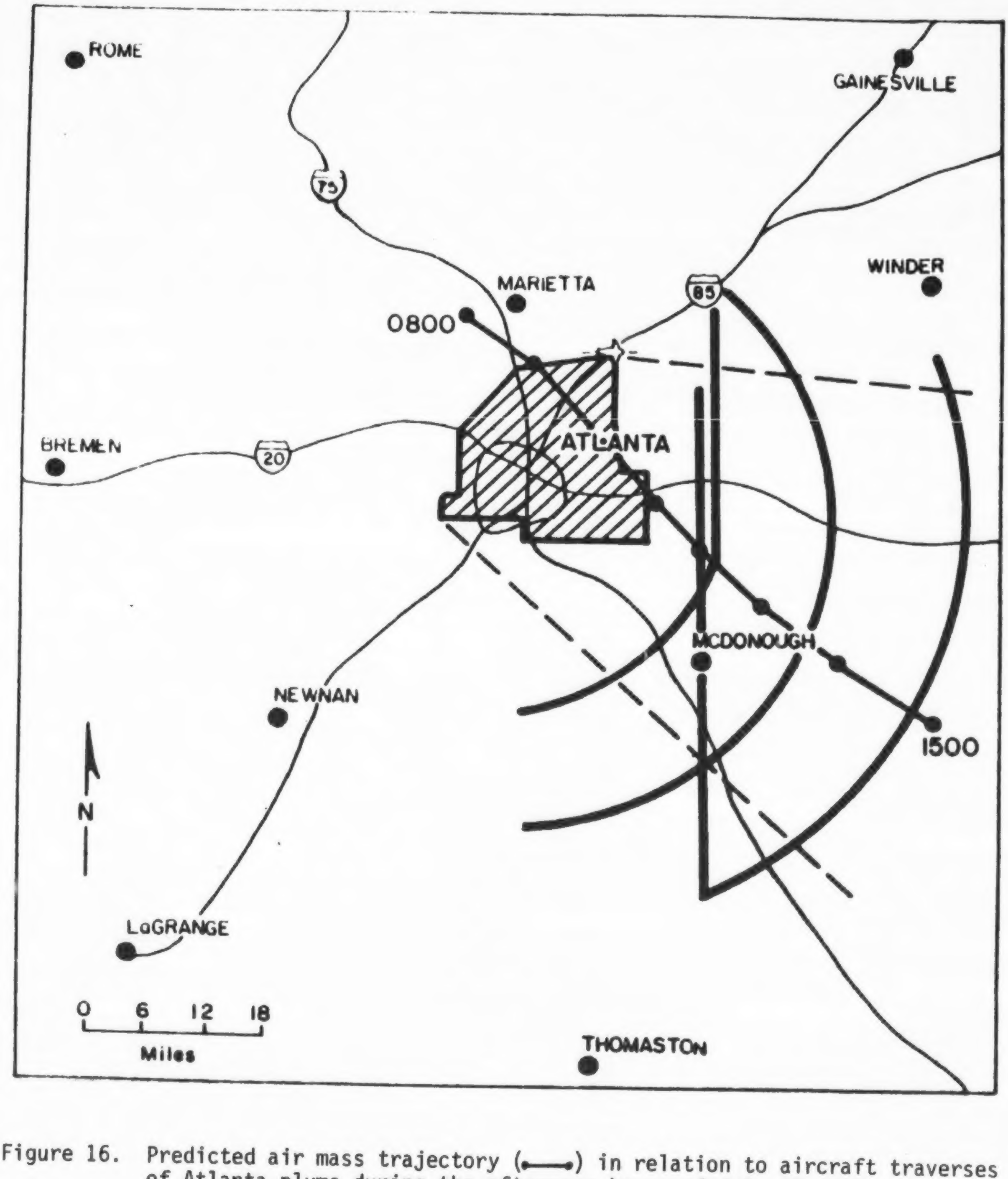


Figure 16. Predicted air mass trajectory (•——•) in relation to aircraft traverses of Atlanta plume during the afternoon hours of July 17, 1981.

the ozone predictions from OZIPP can be compared with aircraft observations for testing the prediction capabilities of the model. The predicted maximum of 142 ppb for July 17 was approximately 10% less than that observed.

As discussed previously, near stagnant conditions prevailed on July 24. The trajectory analysis for this day reflects the light and variable wind conditions. The air mass initially over the city during the morning hours moved slowly to the southwest and then circled back toward the city in the early afternoon. The maximum ozone predicted by OZIPP for July 24 was 153 ppb at about 4:00 p.m. The average ozone concentrations for the three urban/suburban Atlanta monitoring stations (D-P, GT and DCC) was 161 ppb at 5:00 p.m. (this corresponds to the 4:00-5:00 time period). Thus the predicted ozone concentration was only 5% below that measured across the Atlanta urban region.

July 15

As shown in Table 18, the agreement between predicted and observed ozone concentrations on July 15 is extremely good. Wind conditions on July 15 were similar to those described for July 17. Thus the urban emissions were advected to the southeast of Atlanta with ozone concentrations in the 135 ppb range observed 45 miles downwind of the city during the afternoon hours. The OZIPP predicted ozone maximum was 133 ppb.

The good agreement between predicted and observed ozone concentrations in the air masses departing the Atlanta urban area during the 6-9 a.m. period implies that the EKMA procedure could be employed to calculate ozone precursor control requirements in the region. However, with the current ozone monitoring network it would be difficult to define an ozone design value for Atlanta.

Additional continuous monitoring stations would be needed in the urban center as well as in the southeast sector.

EMISSION INVENTORIES

In this section, we will provide an estimate of oxidant precursor emissions in the Atlanta area. Anthropogenic hydrocarbon and nitrogen oxides emissions as well as natural hydrocarbon emissions were estimated for a 97 km x 97 km (60 mi x 60 mi) square centered over downtown Atlanta.

Anthropogenic Emission Inventory

Georgia Department of Natural Resources personnel provided estimates of point and area source annual nitrogen oxides emission rates for the Atlanta area (10). These data are summarized in Table 19. NO_x point source emissions for the area show a total of 41,000 tons/year which is approximately 15% of the total NO_x emissions.

TABLE 19. ANNUAL EMISSION RATES OF NO_x FROM POINT AND AREA SOURCES

	NO_x (tons/yr)	NO_x (tons/day)
Point Sources	41,000	112
Area Sources	234,000	641
TOTAL	275,000	753
Average Grid*	279	0.76
Highest Grid*	4,110	11.3

* 3.2 x 3.2 km grids

The distribution of area source NO_x emissions was obtained from a gridded (3.2 km grids) map of the Atlanta region covering a 108 km by 93 km (68 mi x 58 mi) area centered about downtown Atlanta. As indicated in Table 19, the average grid emission rate for NO_x was 279 tons/yr, and the highest grid emission rate was 4,110 tons/yr.

Estimates of nonmethane hydrocarbon emissions from different source types were also provided by the state of Georgia (10). These data are listed in Table 20 for 1977 and 1982. Results for 1981 to correspond to the field study period are linearly interpolated from the 1977 and 1982 figures. The hydrocarbon emissions data indicate that stationary sources contributed 35% of the total in 1977 and 47% of the total in 1982. In contrast, vehicular hydrocarbon emissions accounted for 54% of the total in 1977, but this source

TABLE 20. ANNUAL EMISSION RATES FOR NONMETHANE HYDROCARBONS

Source	NMHC (tons/yr)		
	1977	1981*	1982
Stationary sources	66,500	58,400	56,300
Vehicles	102,000	55,100	43,400
Aircraft	14,600	15,300	15,500
Other mobile	4,220	4,440	4,500
Total	187,000	133,000	120,000
Average Grid#	189	135	121
Highest Grid#	3,740	2,660	2,400

* interpolated from 1977 and 1982 estimates
# 3.2 x 3.2 km grids

accounted for 35% of the total in 1982. Total nonmethane hydrocarbon emissions decreased from approximately 187,000 tons/yr in 1977 to 120,000 tons/yr in 1982. The interpolated total for 1981 is 133,000 tons/yr.

Results obtained from the gridded emissions inventory for hydrocarbons and interpolated to agree with the 1981 total yielded an average grid emission rate of 135 tons/yr. The maximum grid emission rate for hydrocarbons was 2,660 tons/yr.

On a weight basis, these emission estimates yield a HC/NO_x ratio of 0.48. Conversion to a ppbC/ppb NO_2 ratio yields 1.5 if it is assumed that the typical hydrocarbon molecular weight is 72.5 ($CH_{2.5}$ x 5 carbons) and the NO_x molecular weight is 46. This HC/NO_x ratio of 1.5 is considerably lower than the observed ambient HC/NO_x ratio which averaged about 9. This implies that either the NO_x emissions have been overestimated or the hydrocarbon emission rates are underestimated.

To examine this discrepancy, a simple box model can be used to predict NO_x and NMHC ambient concentrations associated with the respective source strengths:

$$C = \frac{Q}{uLW} \qquad (1)$$

where Q is the total urban emission rate, u is a typical wind speed (10 mph), L is a typical 6-9 a.m. morning mixing height (1500 ft), and W is the width of the urban area (20 mi). For NO_x urban emissions, application of eq. (1) yields an ambient concentration equal to 65 ppb which is essentially identical to the observed NO_x average concentration of 56 ppb during the morning hours. In the case of NMHC emissions, however, the predicted concentration equals 99 ppbC and the average observed concentration was 491 ppbC. This simple modeling analysis suggests that the discrepancy in the ratio of HC/NO_x

emissions is the result of significant underestimation of anthropogenic hydrocarbon emissions.

Natural Hydrocarbon Emission Inventory

During the study period, a vegetation enclosure technique was used to measure hydrocarbon emission rates from the predominate tree species in the Atlanta area. As indicated in Table 21, twenty enclosure samples were collected from four deciduous species dominant in the Atlanta area (white oak, southern red oak, sweetgum, and tulip tree) and from loblolly pine. Naturally emitted hydrocarbons included isoprene, alpha-pinene, beta-pinene, Δ-carene, myrcene, and d-limonene. Isoprene was the predominant emission from the deciduous species, with the exception of the tulip tree which emitted little or no isoprene. Alpha-pinene was a significant emission from loblolly pine.

The existence of an exponential relationship between biogenic emission rates and temperature has been clearly established (11). In the present case, both isoprene and alpha-pinene emission rates (greater than 1 μg/g·hr) were exponentially correlated with enclosure temperatures; the correlation coefficients for isoprene and alpha-pinene were 0.72 and 0.89. The regression lines for isoprene vs. enclosure and ambient temperatures are shown in Figure 17. These lines are given in terms of isoprene flux in comparison to results from a similar emission sampling program conducted in a Pennsylvania hardwood forest in 1979 (11). The biomass factor determined for the Pennsylvania site was used with the Atlanta data as a basis for comparison in Figure 17. The slope of the lines agree quite well with the Pennsylvania results and the magnitude of the emissions are also similar, particularly in view of the different species, climate, and soil conditions involved in the two study sites.

TABLE 21. BIOGENIC HYDROCARBON EMISSION RATES, ATLANTA, 1981

	Vegetation	Date	Time (EDT)	Amb. Temp. (°C)	Encl. Temp. (°C)	Dew Temp. (°C)	Wind Speed (m/s)	Wind Direct. (deg)	Solar Radiation (ly/min)	Emission Rate(μg/g-hr) Isoprene	α-Pinene
1.	Loblolly Pine	7-14-81	0752	25.1	25.3	18.8	2.1	292	0	-	*
2.	Loblolly Pine	7-14-81	1449	31.9	43.3	19.4	3.6	297	1.3	-	10.6
3.	White Oak	7-15-81	1000	26.4	28.9	19.9	2.3	296	0.3	*	-
4.	White Oak	7-15-81	1245	31.0	32.8	21.9	2.9	326	1.1	*	-
5a.	Loblolly Pine	7-16-81	1030	28.1	33.3	21.8	2.7	248	0.6	-	1.84
b.	Loblolly Pine	7-16-81	1030	28.1		21.8	2.7	248	0.6	-	1.18
6.	White Oak	7-17-81	1039	-	28.9	-	-	-	-	*	-
7.	Southern Red Oak	7-20-81	0950	25.3	27.2	20.9	2.5	262	0.3	*	-
8.	Southern Red Oak	7-20-81	1441	31.6	32.8	21.2	2.9	285	0.7	12.2	-
9.	Sweetgum	7-21-81	1024	25.7	26.7	14.8	2.9	297	0.7	*	-
10.	Tulip Tree	7-21-81	1546	31.6	32.2	15.9	4.5	277	1.3	*	-
11.	Loblolly Pine	7-23-81	1003	25.5	28.3	16.1	3.7	82	0.7	-	1.37
12.	White Oak	7-23-81	1412	30.5	33.3	17.4	2.0	65	1.2	21.9	-
13.	Loblolly Pine	7-24-81	1603	33.6	38.9	17.3	1.9	256	1.0	-	11.4
14.	Sweetgum	7-25-81	1256	28.4	32.2	19.1	2.0	295	1.0	46.1	-
15.	Tulip Tree	7-25-81	1316	-	32.2	-	-	-	-	*	-
16.	Southern Red Oak	7-27-81	0917	23.8	23.3	23.8	1.4	329	0.3	5.3	-
17.	White Oak	7-27-81	0942	23.8	23.3	23.8	1.4	329	0.3	4.0	-
18.	Sweetgum	7-29-81	1254	28.1	31.1	19.9	2.5	244	0.7	52.1	-
19.	Loblolly Pine	7-29-81	1318	29.1	33.3	20.2	2.7	246	0.7	-	2.37
20.	Southern Red Oak	7-30-81	1432	23.0	22.8	15.6	5.0	87	0.9	13.4	-

Samples 5a and 5b from the same branch enclosure, but with different enclosure periods; (a) branch enclosed for 6 minutes and (b) branch enclosed for 10 minutes.

* No detectable emission rate.

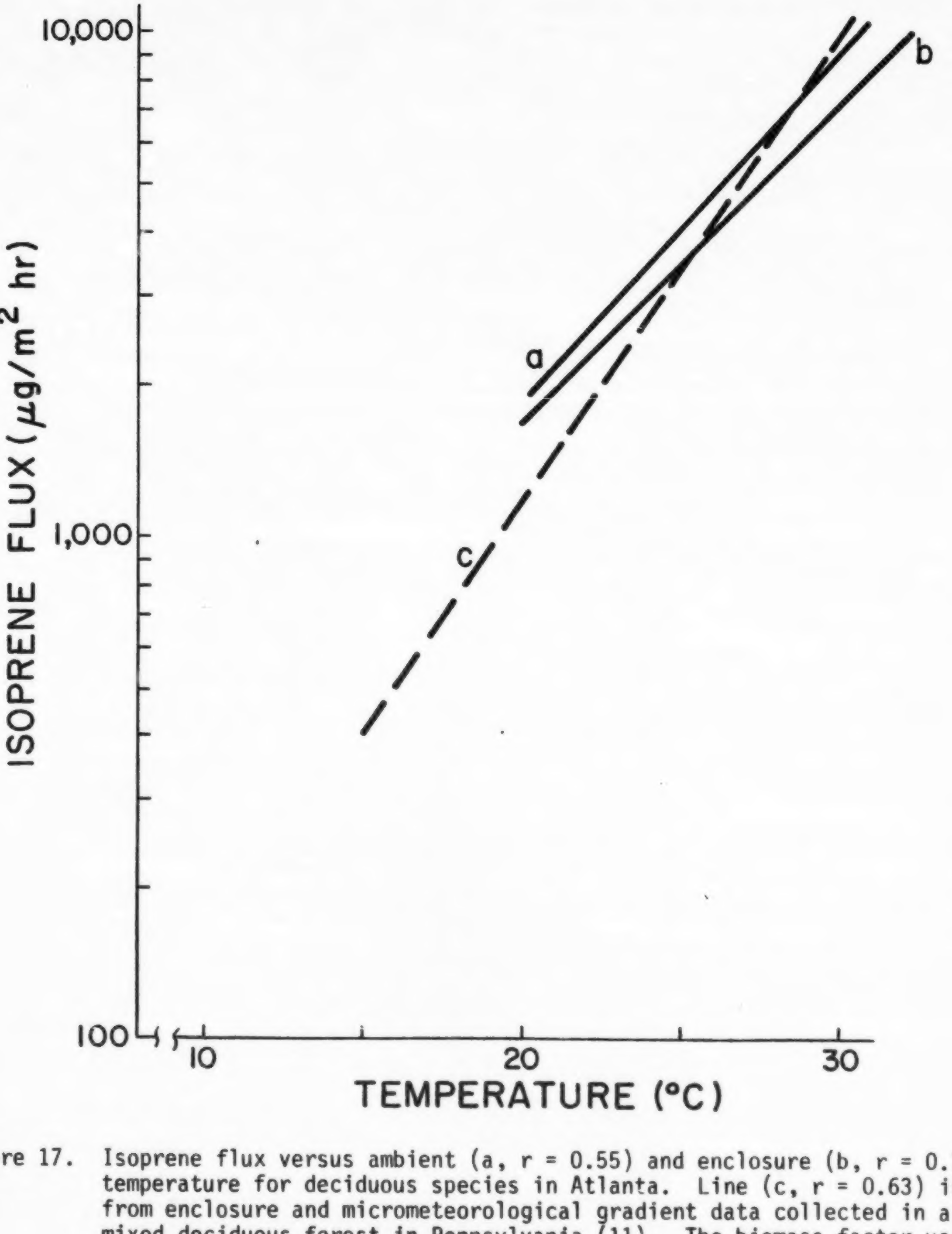


Figure 17. Isoprene flux versus ambient (a, r = 0.55) and enclosure (b, r = 0.72) temperature for deciduous species in Atlanta. Line (c, r = 0.63) is from enclosure and micrometeorological gradient data collected in a mixed deciduous forest in Pennsylvania (11). The biomass factor used for lines (a-c) was 379 g/m^2.

The alpha-pinene emission rates predicted from the temperature regression line at 20°C and 30°C equal 0.23 and 1.3 μg/g·hr. In comparison, Knoerr and Mowry (12) reported emission rates from loblolly pine in North Carolina obtained with an enclosure method in the range 1.2 to 32 μg/g·hr for temperatures between approximately 18°C and 44°C. Arnts et al. (13) also conducted measurements on a loblolly pine forest and estimated emission rates in the range .02 to 2.7 μg/g·hr adjusted to a temperature of 37°C.

In order to apply the results from the enclosure sampling program to the development of an emission inventory, the distribution of forested lands in the Atlanta area was needed and appropriate biomass factors (g/m^2) had to be specified for the forested areas. Descriptions of land use in the Atlanta area were taken from compilations of 10 land use categories in terms of 20 km square grids (14). These data were developed by EPA from an analysis of Landsat photographs and USGS topographical maps in preparation for regional models applied to the eastern U.S.

For a 100 km by 100 km area centered about urban Atlanta, the land use data indicated that forested lands accounted for 68% of the total area. Deciduous forests covered 35% of the total; coniferous forests covered 6% and mixed stands of deciduous and coniferous species occurred over 27% of the area.

Specification of the biomass factors appropriate to the above land use categories rely on published estimates from similar forests. Zimmerman (15) analyzed biomass estimates from a number of sources and developed factors for deciduous and coniferous forests equal to 450 and 650 g/m^2. For comparison, Lamb et al. (11) performed a tree inventory of a mixed hardwood Pennsylvania forest to determine the average tree diameter for use in available biomass algorithms. The resulting factors for isoprene emitting and non-isoprene emitting species were 379 and 206 g/m^2. Arnts et al. (13) reported a range of biomass factors between 440 to 634 g/m^2 for a loblolly pine forest, and Allwine et al. (16) estimated factors between 574 and 1033 g/m^2 for a pure stand of Oregon white oak. Because of the lack of additional data directly related to Atlanta vegetation and since the range of biomass factors estimated for other locales is relatively small, the biomass factors developed by Zimmerman for deciduous and coniferous forests appear to be reasonable estimates for the Atlanta inventory.

The land use distributions and biomass factors can be combined with the regression lines of isoprene and alpha-pinene emission rate versus temperature to yield total emission rates for the Atlanta area for each compound. The results of these calculations are shown in Table 22. The average temperature for July (27°C) was used in these estimates. The calculations show that isoprene emissions equal 328 tons/day while alpha-pinene emissions equal 24 tons/day. It is assumed no isoprene emissions occurred during the night.

TABLE 22. ESTIMATED ISOPRENE AND ALPHA-PINENE EMISSION RATES

Forest Type	% of Total Area	Biomass Factor (g/m^2)	Total Emission Rate*			
			Isoprene		α-pinene	
			(μg/s)	(tons/day)	(μg/s)	(tons/day)
Deciduous	35	450	5.0×10^9	238	-	-
Coniferous	6	650	-		7.7×10^7	7
Mixed (isoprene)	13.5	450	1.9×10^9	90	-	
Mixed (α-pinene)	13.5	650	-		1.7×10^8	17
		TOTAL	6.9×10^9	328	2.5×10^8	24

* Calculated for the mean July temperature, 27°C, for a 100 km x 100 km square.

On an area basis these emissions correspond to fluxes of 2500 μg/m^2·hr for isoprene and 90 μg/m^2·hr for alpha-pinene. For comparison, the anthropogenic hydrocarbon estimate is 1,350 μg/m^2·hr averaged over the 97 km x 97 km square, but the anthropogenic flux is 26,000 μg/m^2·hr in the grid with the maximum hydrocarbon flux.

Since biogenic hydrocarbon concentrations were measured in the routine ambient sampling program, it is worthwhile to apply the box model to predict isoprene and alpha-pinene concentrations. With the same conditions as in the previous section and using average flux values adjusted for the average 6-9 a.m. temperature (23.5°C), the predicted concentrations of isoprene and alpha-pinene are 22 μg/m^3 and 0.73 μg/m^3 (40 and 1.3 ppbC). These values are higher than those observed. As indicated previously isoprene accounted for approximately 1% of the observed NMHC (491 ppbC) and total biogenic species accounted for 2% to 7% of the observed NMHC. However, unlike the case for anthropogenic hydrocarbons, the biogenic hydrocarbon inventory appears to yield an upper bound in comparision with observed ambient biogenic hydrocarbon concentrations.

Urban Tracer Experiments

Near the end of the study period, three sulfur hexafluoride (SF_6) tracer tests were conducted in the Atlanta area. The purpose of these experiments was to tag the early morning precursor emissions from downtown Atlanta in order to study the trajectories and dilution rates of gases transported across suburban Atlanta and into the downwind rural areas. Tests 1-3 were conducted on July 28, 30, and August 3, 1981. During each experiment, SF_6 was released continuously for several hours beginning at 0600 from near the surface at the

Georgia Tech monitoring site. Release data and average meteorological conditions measured 50 m above ground level (agl) at Georgia Tech are presented in Table 23. Brief descriptions of the individual tests are given below.

Test 1 7/28/81 --

Meteorological conditions during the first test included moderate west winds throughout the day with relatively clear skies. Results from periodic pilot balloon releases at the Peachtree-DeKalb monitoring site indicated that flow within the mixed layer was uniformly from the west up to 8000 ft. agl; wind speeds varied from 10 to 25 mph during the day.

Four hourly-averaged air samples were collected sequentially at each of ten locations during the tests as indicated in Table 24 and instantaneous air samples were collected manually during 14 automobile traverses along crosswind routes at distances as far as approximately 25 mi downwind of the urban center.

The combined results from the fixed samplers and the automobile traverse data are shown in Figure 18 for the period 0800-1100. These isopleths indicate that the plume initially moved toward the northeast and then shifted to an eastward direction after 0900. Maximum hourly averaged concentrations varied from 42 to 214 ppt during these hours and maximum instantaneous concentrations ranged from 276 ppt to 1273 ppt at distances beyond approximately 10 mi. The tracer data also show that SF_6 released from 0600-0900 was transported out of the sampling area by approximately 1100; no significant tracer concentrations were observed in samples collected from 1100 to 1400.

TABLE 23. TRACER RELEASE AND SURFACE METEOROLOGICAL DATA

Time EDT	Wind Speed (m/s)	Wind Direction (deg)	Temp. (°C)	Sun (%)
Test 1 7/28/81 SF_6 released from 0600-0900 at 10.5 g/s				
0600	0.8	186	26.0	0
0700	2.7	194	25.7	-
0800	2.7	211	25.7	-
0900	3.6	237	26.5	80
1000	4.0	260	28.0	100
1100	4.3	282	30.1	100
1200	4.7	269	31.7	97
1300	5.1	268	32.7	90
1400	4.5	256	33.2	68
1500	4.8	247	33.9	73
1600	4.7	237	34.5	92
1700	5.5	243	34.5	92
1800	5.3	236	34.2	92
Test 2 7/30/81 SF_6 released from 0600-0900 at 13.1 g/s				
0600	3.5	284	21.1	0
0700	2.0	309	20.7	-
0800	2.3	331	20.6	0
0900	2.9	351	20.8	0
1000	1.5	351	21.4	1
1100	4.1	24	23.0	0
1200	6.2	59	21.6	0
1300	6.3	67	22.7	22
1400	6.3	75	23.6	29
1500	6.5	73	23.2	11
1600	6.3	57	23.2	23
1700	6.0	62	23.3	22
1800	5.9	56	23.5	48
Test 3 8/3/81 SF_6 released from 0600-1000 at 13.1 g/s				
0600	1.2	91	21.2	0
0700	2.0	84	21.1	0
0800	1.8	103	20.9	0
0900	1.3	130	21.6	0
1000	1.6	152	22.6	1
1100	1.1	183	24.2	17
1200	1.5	177	26.2	86
1300	1.9	221	27.9	49
1400	2.0	247	29.2	65
1500	2.6	233	30.3	89
1600	3.7	217	30.9	93
1700	3.7	218	31.3	95
1800	2.9	245	31.5	100

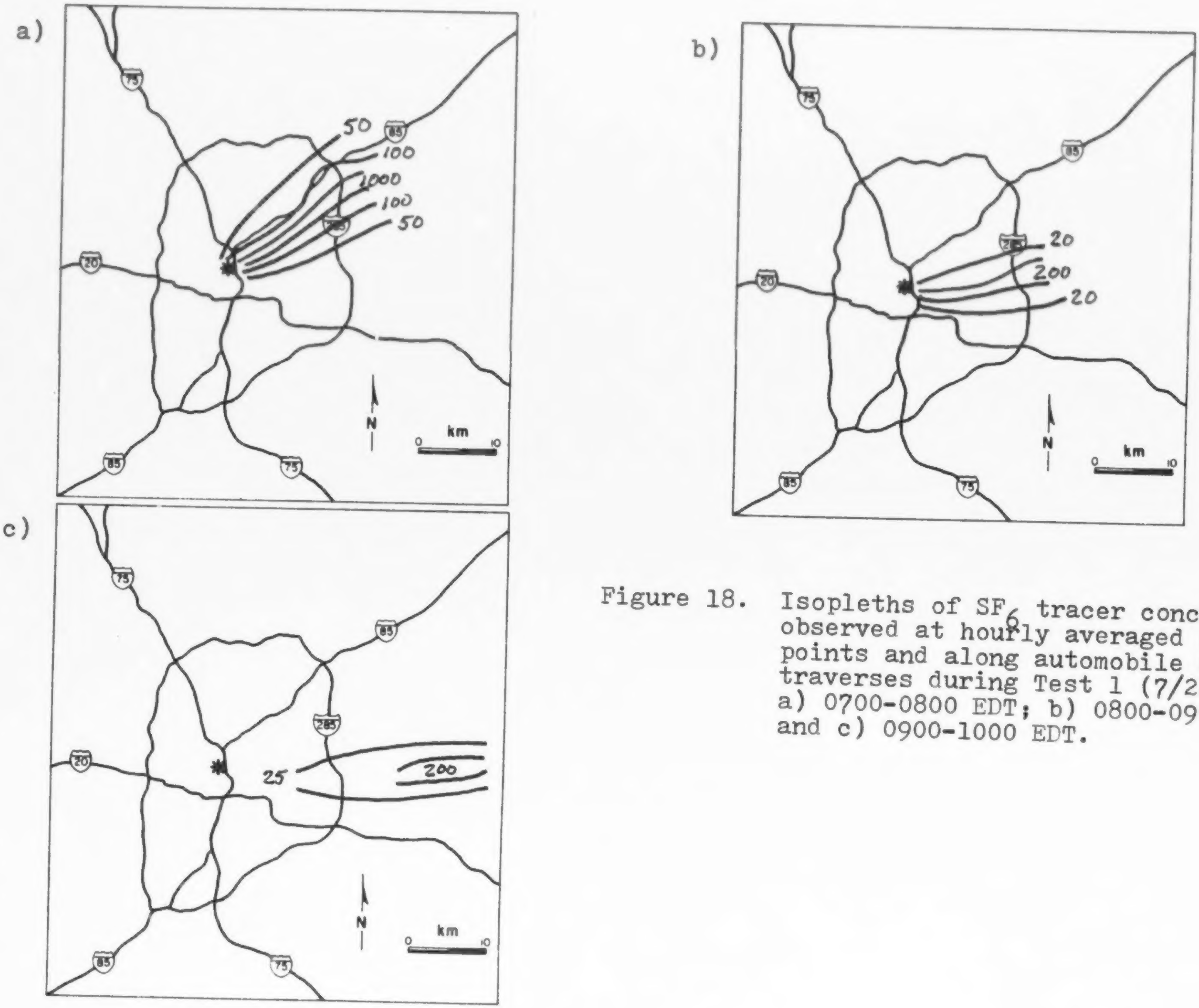


Figure 18. Isopleths of SF_6 tracer concentrations observed at hourly averaged sample points and along automobile sampling traverses during Test 1 (7/28/81): a) 0700-0800 EDT; b) 0800-0900 EDT; and c) 0900-1000 EDT.

TABLE 24. HOURLY-AVERAGED TRACER DATA, TEST 1

Location	r, θ* (km, deg N)		Time (EDT) 8	9	10	11	12	13
					SF_6 (ppt)			
1. 3119 Rosewell Rd.	7.4	15	-	-	-			
2. 2924 Clairmont Rd.	10.9	46	62	3	6	0		
3. 5811 Rosewell Rd.	15.3	8	8	4	0	5		
4. I-285 and Memorial Dr.	15.3	90	0	44	42	0		
5. 3585 N. Crest Rd.	19.3	47	73	11	4	0		
6. Brockett Rd. and Ponce de Leon	17.0	73	0	247	0	0		
7. Crabapple	29.9	10			7	8	6	0
8. GA 20 and GA 9	53.4	27			0	-	-	-
9. GA 20 and Sudderth	52.5	45			0	0	2	11
10. GA 78 and Rosebud Rd.	41.4	79			36	2	0	0

* r = radial distance from source; θ = azimuth angle with respect to the source

Test 2 7/30/81 --

Skies were overcast throughout Test 2 and winds shifted from the northwest in the morning to the northeast through the remainder of the day at approximately 14 mph. Pilot balloon data obtained at 0900 and 1100 were limited to below 1000 ft. agl because of cloud cover; winds in this layer were uniform with height from the northeast.

Hourly-averaged SF_6 concentrations measured at ten locations are tabulated in Table 25. Eleven automobile traverses were also completed during the test. Isopleths of the observed tracer concentrations are shown in Figure 19 for three hours between 0700 and 1200. These figures illustrate how the direction of plume transport shifted from southeast early in the morning to south-southwest by mid-day. Maximum instantaneous concentrations exceeded 6000 ppt within 3 mi of the source and varied between 173 and 548 ppt along

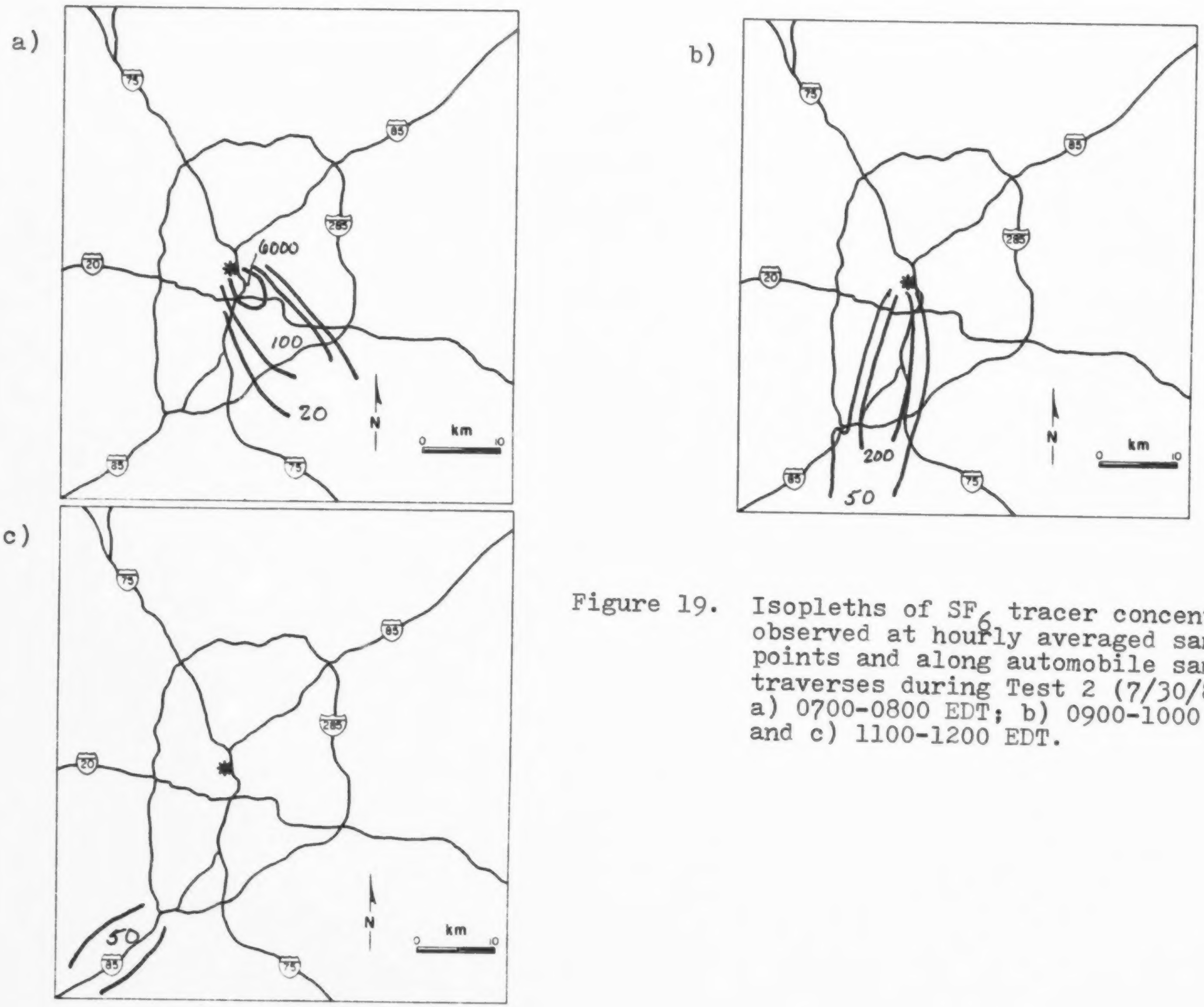


Figure 19. Isopleths of SF_6 tracer concentrations observed at hourly averaged sample points and along automobile sampling traverses during Test 2 (7/30/81): a) 0700-0800 EDT; b) 0900-1000 EDT; and c) 1100-1200 EDT.

I-285 at 12 mi downwind. Maximum hourly averaged concentrations observed along I-285 south of the source ranged from 30 to 179 ppt during the experiment. The data also show that tracer released from 0600-0900 was essentially swept clear of the urban area by noon.

TABLE 25. HOURLY-AVERAGED TRACER DATA, TEST 2

Location	r, θ* (km, deg N)		Time (EDT) SF$_6$ (ppt)						
			7	8	9	10	11	12	13
1. I-285 and Covington Hwy.	16	101	0	0	2	0			
2. I-285 and Flat Shoals Rd.	15	127	0	0	0	0			
3. I-285 and Mooreland Ave.	14	158	30	98	0	0			
4. I-285 and Main St.	17	175	-	36	-	-			
5. I-285 and GA 139	19	190		0	179	116	2		
6. 2045 Main St.	10	197	0	5	66	26			
7. GA 85 and GA 279	30	185				23	0	0	5
8. I-85 and GA 92	31	210				5	74	3	0
9. GA 154 and Cedargrove Rd.	32	234				0	0	0	0
10. I-20 and GA 92	31	264				-	-	-	-

* r = radial distance from source; θ = azimuth angle with respect to the source

Test 3 8/3/81 --

During the last tracer experiment, the meteorological conditions included overcast skies during the morning with some clearing during the afternoon. Winds were light at approximately 2 mph and shifted from southeasterly early in the morning to southwesterly by mid-afternoon. No pilot balloons were released during this experiment.

Hourly-averaged samplers were located at 7 positions during this test, as indicated in Table 26, and 18 automobile traverses were completed between 0721 and 1405. During 12 of the traverses at downwind distances from .5 to 9 mi, a continuous SF_6 analyzer was operated in the traverse vehicle.

TABLE 26. HOURLY-AVERAGED TRACER DATA, TEST 3

Location	r, θ* (km,	deg N)	Time (EDT) 7	8	9	10	11	12
					SF_6	(ppt)		
1. I-285 and Northside Dr.	16	348	5	4	0	33		
2. I-285 and Cobb Dr.	15	329	9	217	305	3		
3. I-285 and Bankhead Rd.	9	278	240	398	-	-		
4. I-285 and Martin Luther King Dr.	9	252	0	0	3	3		
5. I-285 and GA 166	14	224	3	0	0	0		
6. I-20 and Thornton Rd.	20	270			0	0	0	0
7. GA 70 and GA 92	29	240			0	0	0	0

* r = radial distance from source; θ = azimuth angle with respect to the source

Isopleths of SF_6 concentration are shown in Figure 20 for three hours between 0700 and 1400. These data indicate that the plume initially carried west of the urban center and then gradually shifted toward the north during the day. Maximum hourly averaged concentrations varied from 398 ppt along I-285 6 mi downwind at 0800-0900 to 33 ppt 12 mi downwind at 1000-1100. Instantaneous maxima decreased from more than 50,000 ppt within 0.4 mi of the source to approximately 500 ppt observed in traverses along I-285 6 mi downwind. Results from repetitive traverses along I-285 with the continuous analyzer are shown on Figure 21. These quasi-instantaneous profiles show the variability in plume dimensions and concentrations as well as the movement of the mean plume axis northward during the morning. The averages of these various traverses for the periods 0900-1000 and 1000-1100 are plotted in Figure 22 along with the corresponding best-fit Gaussian curves. According to the average crosswind

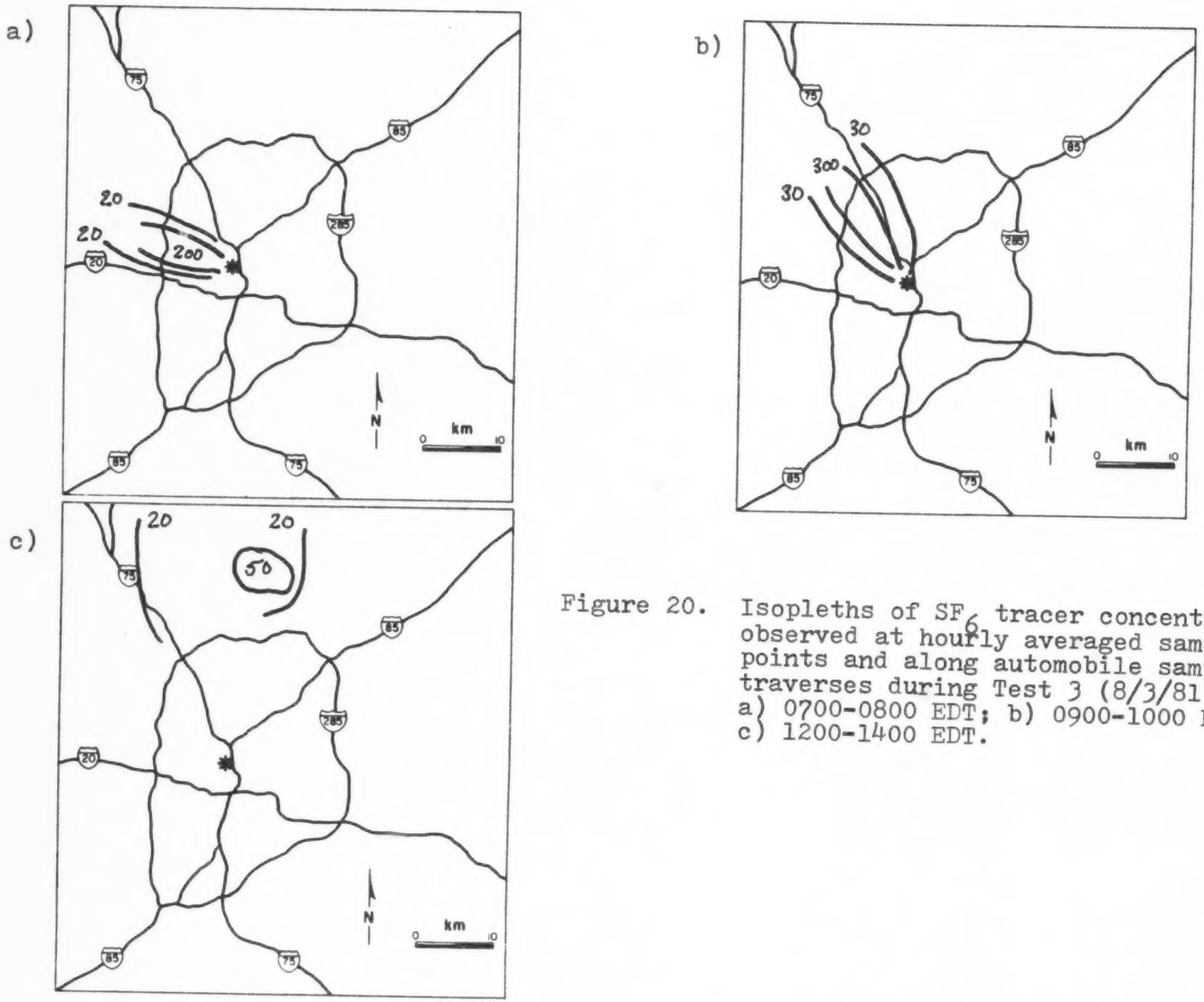
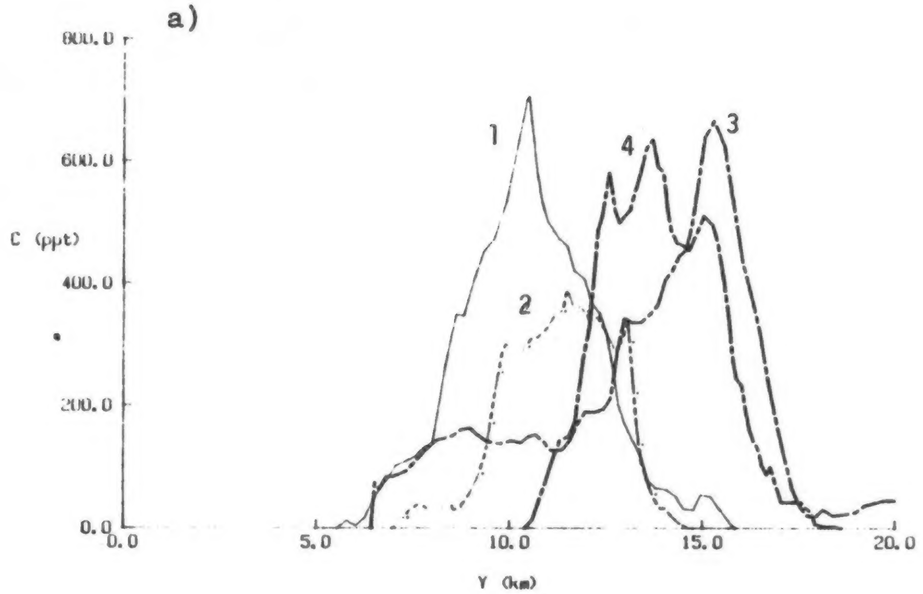


Figure 20. Isopleths of SF_6 tracer concentrations observed at hourly averaged sample points and along automobile sampling traverses during Test 3 (8/3/81): a) 0700-0800 EDT; b) 0900-1000 EDT; c) 1200-1400 EDT.



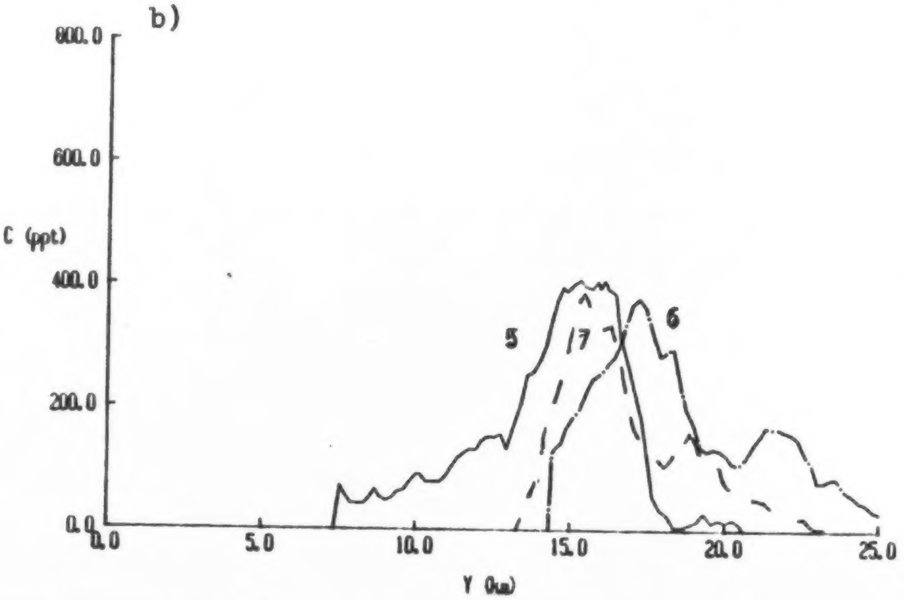


Figure 21. Crosswind concentration profiles of SF_6 obtained with a continuous SF_6 analyzer during automobile traverses along I-285 8 miles downwind of the source: a) 0900 - 1000 EDT and b) 1000 - 1100 EDT. Crosswind distances are in reference to the I-20 - I-285 junction.

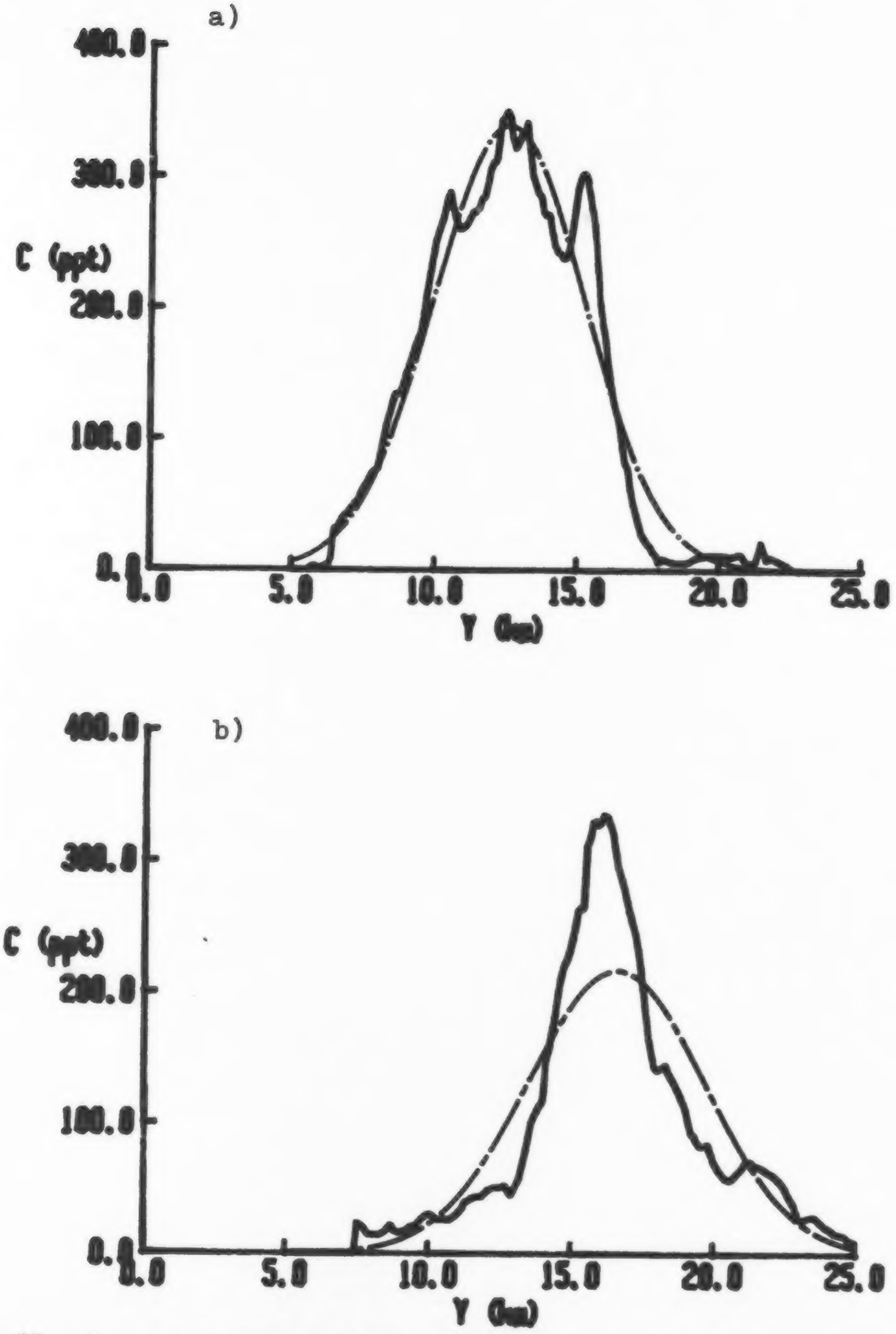


Figure 22. Average crosswind SF_6 concentration profiles (——) and bestfit Gaussian curves (—·—) along I-285 8 miles downwind of the source: a) 0900 - 1000 EDT and b) 1000 - 1100 EDT. Crosswind distances are in reference to the I-20 - I-285 junction.

profiles, the maximum hourly-averaged concentrations were approximately 350 ppt and the standard deviations of the horizontal concentration (σ_y) obtained from a Gaussian best-fit analysis of the profiles were 1.6 and 1.9 mi at 8 mi downwind. For comparison, the corresponding value of σ_y obtained from McElroy-Pooler dispersion curves generated from an urban St. Louis tracer study was only 0.9 mi for unstable conditions (17). The difference in the observed and predicted plume widths is probably related to the gradual change in wind direction which occurred during the crosswind traverse periods.

Trajectory Analysis

One objective in performing the tracer experiments was to evaluate simple trajectory calculations to be used in the application of the city specific OZIPP model. Forward trajectories were calculated for each hour of tracer release using a combination of pilot balloon upper air data and the wind data collected at 50 m by the School of Geophysical Sciences at Georgia Tech. The calculation procedure involved linear interpolation in time (9) and surface data were used to define the wind vectors prior to the first pilot balloon release. During Test 3 where no upper air data were available, trajectories were calculated using surface data alone. Speed and direction data from the available pilot balloon releases were vector averaged from the surface to the mixing height which was defined by linear interpolation between the initial and final mixing heights and times. This approach yields trajectories based upon surface data during the early morning (when the hydrocarbon and NO_x emissions are within a low mixed layer) and based upon the average wind within the mixed layer during the remainder of the day.

Trajectories for Test 1 traced an early morning path north and then east of the city, as shown in Figure 23a. Six a.m. air passed almost over the Peachtree-DeKalb airport at 0800 and reached a point 45 mi east-northeast of Atlanta by approximately 1100. Air parcels leaving the urban center at 0800 traveled almost directly east out of the city and reached 45 mi downwind by approximately 1200.

The path of the tracer plume as observed in the instantaneous and time-averaged samples generally agreed with the results of the trajectory analysis. As shown by comparing Figures 18 and 23a, the calculated trajectories passed through the locations where tracer concentrations were observed at very close to the time of observation. For example, 28 mi northeast of the city the hourly average tracer concentration was 36 ppt from 1000-1100 and zero in the following periods. The wind trajectories indicate that the plume passed very close to the sample point and had, indeed, gone past the point by approximately 1100.

During Test 2, the trajectories outline a path first to the southeast and then curving toward the southwest. The isopleths in Figure 19 and the trajectories in Figure 23b show the same pattern. For tracer emitted between 0600-0700, the tracer data and the trajectories indicate transport past I-285 southeast of the release between 0700 and 0800. For later release times, the trajectories show slightly more westward travel than is apparent in the tracer data, but the overall agreement is relatively good.

A similar comparison of Figures 20 and 23c for Test 3 yields a similar degree of agreement. Early morning emissions traveled directly west while releases later in the morning were carried to the northwest. The trajectories indicate that tracer released from 0900-1000 traveled north across I-285

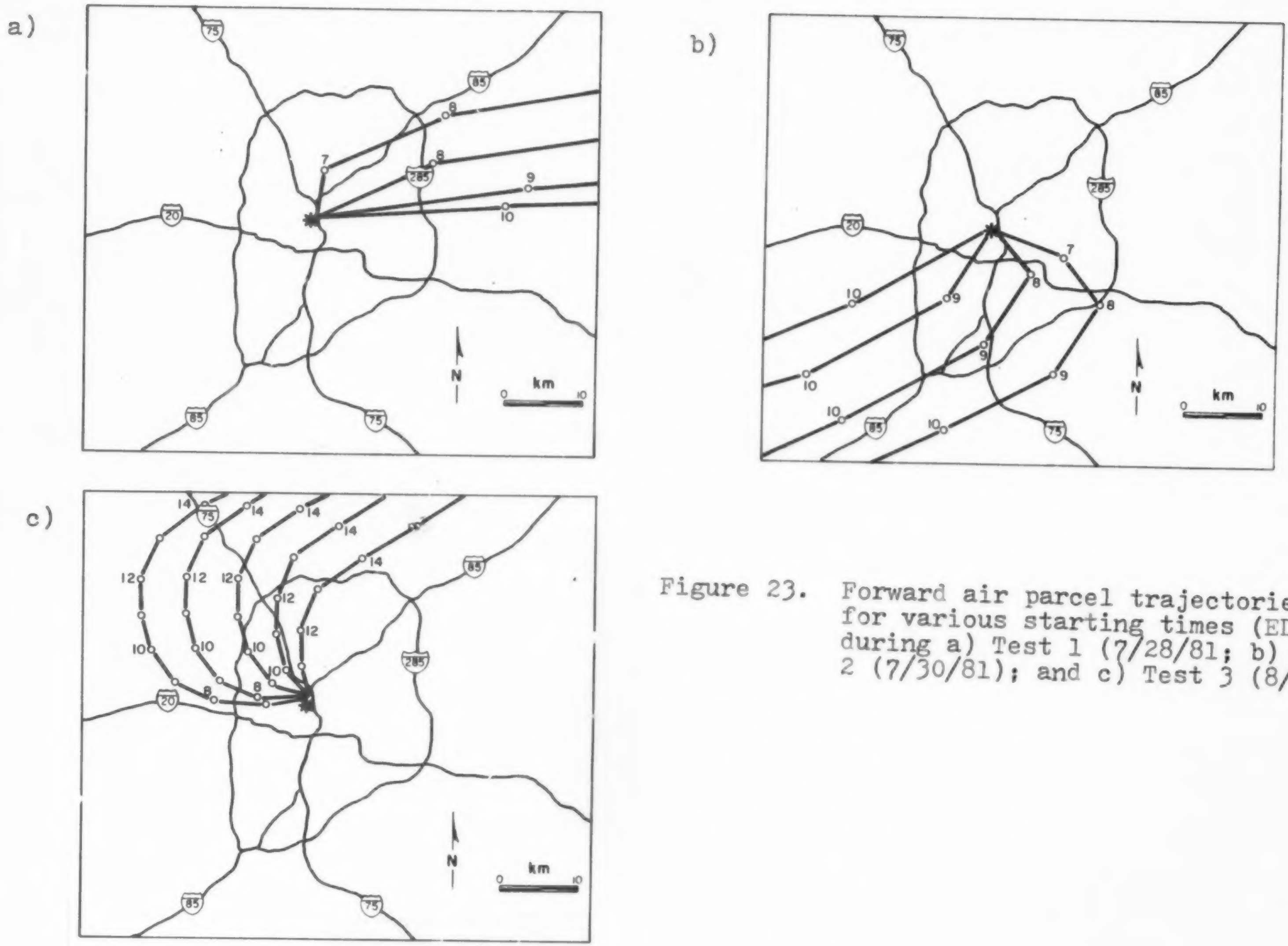


Figure 23. Forward air parcel trajectories for various starting times (EDT) during a) Test 1 (7/28/81; b) Test 2 (7/30/81); and c) Test 3 (8/30/81).

between 1000-1100 and the results from the continuous analyzer show agreement with such a path.

The good agreement between the tracer data and the trajectory results indicate that surface winds combined with upper level winds from a single station, averaged over the mixed layer, produce reasonable estimates of plume trajectories in the flat, open country of the Atlanta area. As a result, this kind of trajectory analysis will be useful in the evaluation of trajectory air quality models such as used in EKMA. It should be recognized, however, that the agreement between tracer results and the trajectories obtained in the present case was limited to less than approximately 50 km. The errors involved in any trajectory analysis will increase with increasing transport time.

REFERENCES

1. Climates of the States Vol. I. - Eastern States. Water Information Center, Inc., Port Washington, New York, 1974.

2. Lonneman, W.A. Computerized Atlanta Area Hydrocarbon Data Are Available Upon Request, U.S. Environmental Protection, Research Triangle Park, NC.

3. Freas, W. P. Selection of a Default NMOC/NO_x Ratio for Use in Ozone Regulatory Impact Analyses. OAQPS, MDAD, AMTB, April 1983.

4. Atlanta Metropolitan Area Transportation Pollutant Study: July 1975 - May 1976. Georgia Department of Natural Resources, Environmental Protection Division, Atlanta, GA, 1976.

5. Measurement of Light Hydrocarbons and Oxidant Transport - Houston Area 1976. EPA-600/3-78-062, U.S. Environmental Protection Agency, Research Triangle Park, NC, 1978.

6. Lonneman, W.A., J. J. Bufalini, and R. L. Seila. PAN and Oxidant Measurement in Ambient Atmospheres. Environ. Sci. Technol., 10:374, 1976.

7. Altshuller, A.P. Measurements of the Products of Atmospheric Photochemical reactions in Laboratory Studies and in Ambient Air--Relationships Between Ozone and Other Products. Atmos. Environ. 17:2383, 1983.

8. User's Manual for Kinetics Model and Ozone Isopleth Plotting Package EPA-600/8-78-014a, U.S. Environmental Protection Agency, Research Triangle Park, NC, 1978.

9. Benkley, C. W., and A. Bass. Development of Mesoscale Air Quality Simulation Models: Volume 6. Users's Guide to MESOPAC. EPA-600/7-80-061, NTIS PB80-228042, 1979.

10. Personal communication. Point and Area Source NO_x and Hydrocarbon Emissions Inventory. Georgia Department of Natural Resources, Atlanta, Georgia, 1984.

11. Lamb, B., H. Westberg, G. Allwine, and T. Quarles. Biogenic Hydrocarbon Emissions from Deciduous and Coniferous Species in the U.S. Accepted for publication, J. Geophys. Res., 1983.

12. Knoerr, K. R., and F. L. Mowry. Energy Balance/Bowen Ratio Technique for Estimating Hydrocarbon Fluxes. In: Atmospheric Biogenic Hydrocarbons. Ann Arbor Science Publishers, Inc., Vol. 1, 1981, p. 35.

13. Arnts, R. R. R., W. B. Petersen, R. L. Seila, and B. W. Gay, Jr. Estimated of Alpha-pinene Emissions from a Loblolly Pine Forest using an Atmospheric Diffusion Model. Atmos. Environ., 16:2127, 1981.

14. Page, S. H. National Land Use and Land Cover Inventory. U.S. Environmental Protection Agency, Las Vegas, NV, 1980.

15. Zimmerman, P. R. Testing of Hydrocarbon Emissions from Vegetation and Methodology for Compiling Biogenic Emission Inventories. In: Atmospheric Biogenic Hydrocarbons. Ann Arbor Science Publishers, Inc., Vol. 1, 1981, p. 15.

16. Allwine, G., B. Lamb, and H. Westberg. Application of Atmospheric Tracer Techniques for Determining Biogenic Hydrocarbon Fluxes from an Oak Forest. Presented at the Forest Environmental Measurements Conference, Oak Ridge, TN, 1983.

17. McElroy, J. L. A Comparative Study of Urban and Rural Dispersion. J. Appl. Meteor., 8:19-31, 1969.

APPENDIX A

Quality Assurance Document

Quality Assurance Document

ATLANTA AIR QUALITY STUDY

1981

for

Environmental Protection Agency
Research Triangle Park, NC 27711

Project Officer
William Lonneman

by

Washington State University

SECTION 1

PROJECT SUMMARY

The primary goals of this research program were to monitor oxidant precursor emissions in Atlanta and to study ozone production and transport in the region downwind of the city. A field sampling period of 22 days (July 13 - August 3, 1981) was utilized for gathering air quality data in the Atlanta region. The monitoring network included surface stations and an aircraft sampling platform. Hydrocarbons, oxides of nitrogen, and ozone as well as other gaseous pollutants and various meteorological parameters were measured throughout the region from the Atlanta City Center out to a radius of approximately 50 miles.

Washington State University operated an instrumented aircraft which was based at the DeKalb-Peachtree Airport. Aircraft flights were used to define pollutant levels in air masses advected into the Atlanta region during the morning hours and to document ozone production and transport in the Atlanta plume during the afternoon hours. A total of 23 sampling missions were flown during the study period.

SECTION 2

AIRCRAFT STUDIES

AIR QUALITY INSTRUMENTATION

Air quality instrumentation employed in the aircraft is listed in Table A-1. In addition, this table includes: 1) instrument range settings employed during the study, 2) instrument resolution, and 3) instrument response time (90% of full scale). Table A-2 summarizes precision and accuracy data for the ozone monitor and the oxides of nitrogen analyzer. The precision value is based on repetitive span checks conducted throughout the study period (see Tables A-3 and A-4). Accuracy is based on U.S. EPA Region IV field audit results (1).

AIRCRAFT DESCRIPTION

An instrumented Cessna 402 was used for airborne sampling. A low wing, twin engine airplane, the 402 is able to carry a pilot, an instrument operator and approximately 600 pounds of equipment. Air for analysis is brought into the aircraft through a 4-inch diameter sampling probe extending approximately 10-inches outboard of the right side of the fuselage. The probe is connected to a 4-inch diameter, clear plexiglass manifold inside the aircraft which extends down the right side of the cabin. Air from the sampling manifold enters the instruments through ¼-inch Teflon tubing. The large size of the sampling probe and manifold provide ample air flow for all equipment.

A Topaz solid-state inverter is used to convert the 28 VDC aircraft generator output to 120 VAC for operating the air pollutant analyzers.

TABLE A-1. AIRCRAFT AIR QUALITY INSTRUMENTATION.

Parameter	Instrument (S/N)	Analysis Technique	Ranges	Resolution	Response Time (sec)
Ozone	CSI 2000 (8038)	Chemilum	0-200(a) 0-500	~5(a)	~5
NO/NO_x	ML 8440 HP (1226)	Chemilum	0-200(a)	~5(a)	~5
Visual range	MRI 2050 (216)	Nephel.	.3 - ∞(b)	.3(b)	~1
Condensation nuclei	Environment One-Rich 100 (145)	Light Attenuation	10^3 - 10^6(c)	~10^3(c)	3
Temperature	Metrodata M-8 (100)	Bead Thermister	-50 - +50(d)	0.5(d)	5
Relative Humidity	Metrodata M-8 (100)	Carbon Strip	30 - 95(e)	8(e)	5

a units = ppb
b units = miles
c units = cm^{-3}
d units = °C
e units = %

TABLE A-2. PRECISION AND ACCURACY RESULTS

Parameter	Model	Precision (% SD)	Accuracy (%)	Noise (% fs)	Altitude Corrected
O_3	CSI 2000	1.1 (a)	3.5 (b)	2	yes
NO_x	ML 8440 HP	0.5 (c)	7.4 (d)	3	no

(a) Based on in-flight span checks
(b) Based on EPA Region IV audit
(c) Based on ground-level span checks
(d) Based on EPA Region IV audit

TABLE A-3. CSI 2000 OZONE MONITOR SPAN DATA

Date	Response (ppb)	Date	Response (ppb)
7/13/81	260	7/23/81	264
7/14/81	265	7/25/81	265
7/16/81	265	7/29/81	270
7/17/81	265		
Mean value:		265	
Standard Deviation:		3	
% Standard Deviation:		1.1	

TABLE A-4. NO/NO$_x$ SPAN DATA FOR MONITOR LABS 8440 ANALYZER

Date	Response (ppm) NO	NO$_x$
7/12	.932	.960
7/14	.942	.956
7/16	.938	.960
7/18	.942	.950
8/6	.930	.950
Mean:	.937	.955
Standard Deviation:	.006	.005
% Standard Deviation:	0.6	0.5

This inverter provides about 1000 watts of usable power. Figure A-1 provides a schematic diagram of the airborne laboratory.

AIRCRAFT SAMPLING

The aircraft was stationed at DeKalb-Peachtree Airport in northeast Atlanta. Two flights were conducted on most days. A morning flight between the hours of 8-11 a.m. was utilized to establish mixing heights and ozone transport into the Atlanta region. A typical morning flight path is illustrated in Figure A-2. The flight began with a spiral ascent to about 8000 ft near the Norcross VOR northeast of Atlanta. The plane then made a counterclockwise circle of 30 mile radius around Atlanta. Flight altitude for this circle was generally 2500 ft above the surface. The instrumented aircraft then made a pass directly over the city center followed by a return to the airport along the eastern edge of the city.

The afternoon flight (~1-4 p.m.) was used to monitor ozone production in the Atlanta plume. As shown in Figure A-3, a series of crossplume arcs were flown at varying distances downwind of Atlanta. Traverses at various altitudes as well as a spiral ascent near Norcross provided afternoon mixing height information.

Aircraft sampling speeds varied between 130-160 mph. At spiral points, the aircraft ascent and descent rate was 500 ft/min with standard 2° turns. The aircraft was equipped with Cessna navigational instruments and receivers. Certified accuracy of the altimeter was ±100 ft. The accuracy of the air speed indicator was ±1%. Aircraft Radio Corporation (Cessna) receivers were employed for obtaining VOR and DME readings. VOR accuracy was certified to be within ±4° and DME accuracy was ±2%.

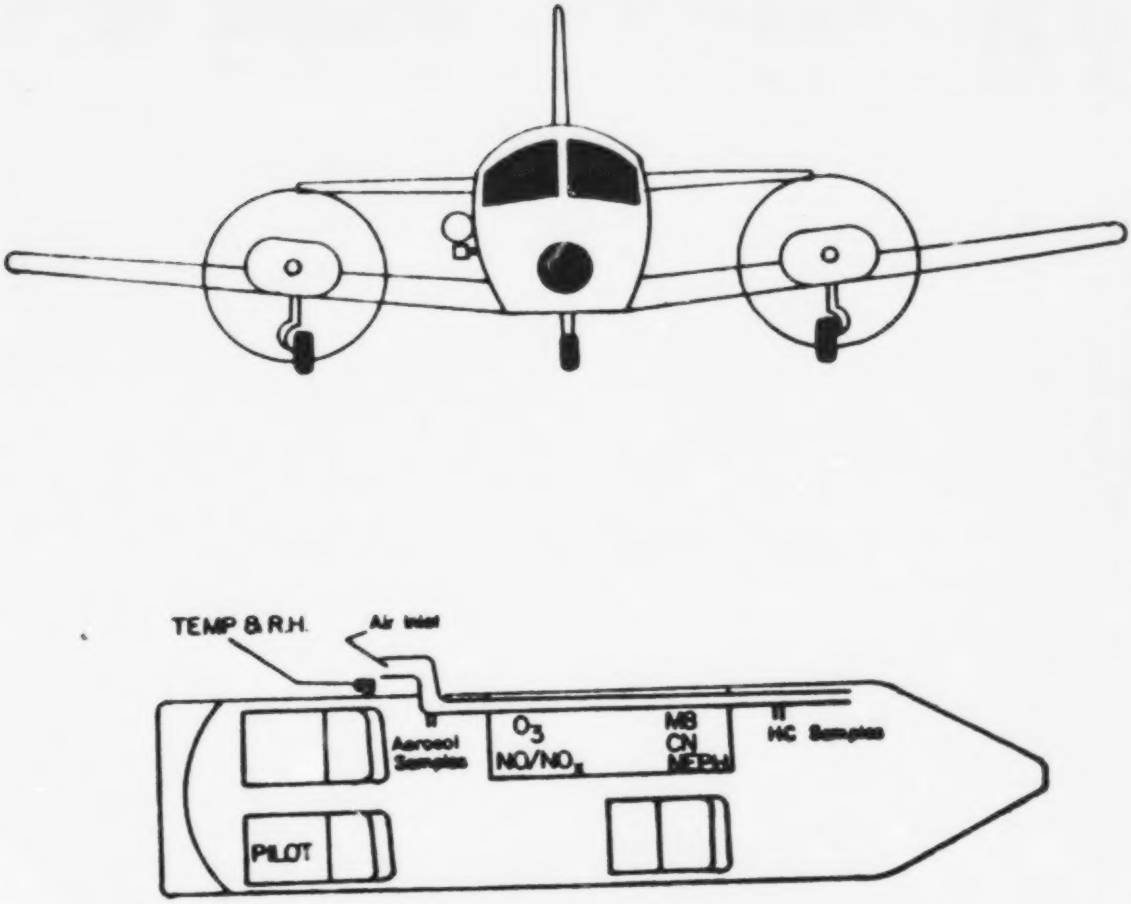


Figure A1. Diagram of the Airborne Laboratory.

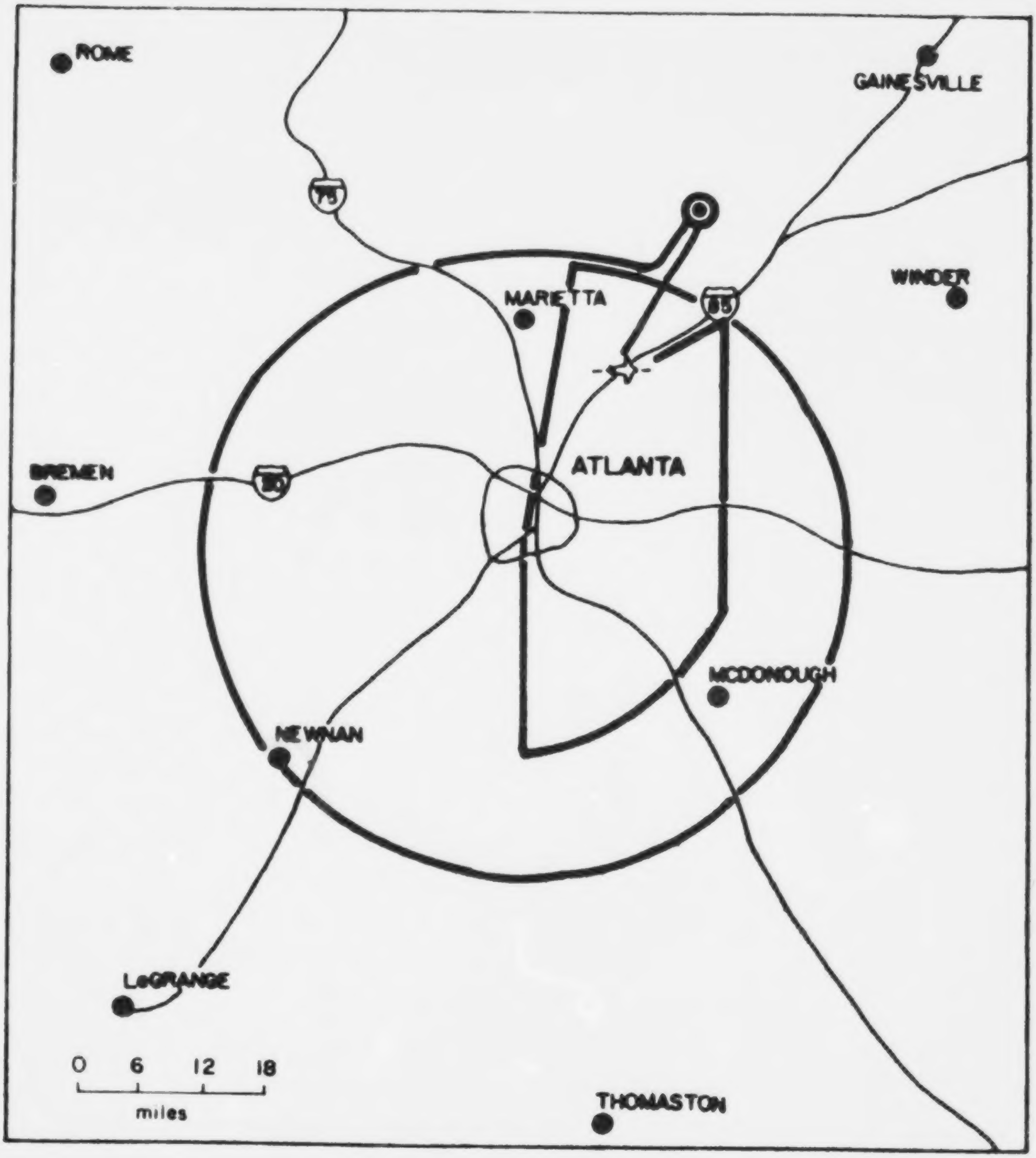


Figure A2. Typical Morning flight path.

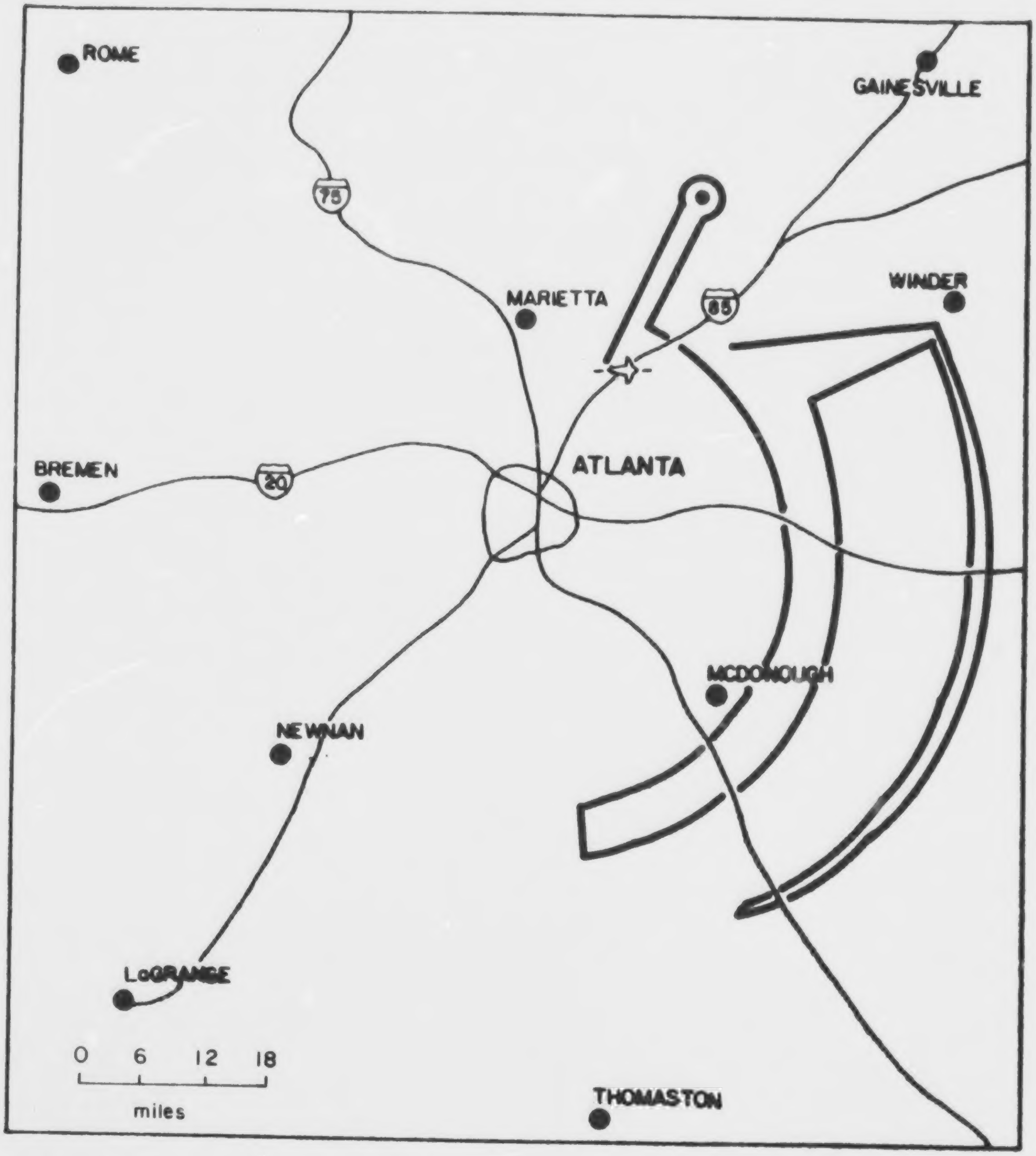


Figure A3. Typical afternoon flight path.

CALIBRATION PROCEDURES

A summary of calibration procedures for each air quality monitor is outlined below. Table A-5 lists calibration data for the O_3 and NO/NO_x analyzers.

Ozone - A multi point calibration was performed on the airborne ozone analyzer four times during the study period (7/9, 7/18, 7/24, and 7/28/81). A MEC 1000 ozone generator was utilized to provide known concentrations in the 0-200 ppb range. Ozone generator output was established by UV photometry. At no time did the results indicate a need to adjust calibration settings on the CSI 2000 ozone monitor (instrument response varied less than 10% throughout the study period).

Oxides of nitrogen - The airborne oxides of nitrogen analyzer was span checked on 7/12, 7/14, 7/16, 7/18, and 8/6 using a 0.93 ppm NO tank obtained from AIRCO (see Table A-4). The tank concentration was verified by gas phase titration at the WSU laboratory. Prior to the field study, a comprehensive calibration check was performed on the ML 8440 HP in our home laboratory. Various nitric oxide concentrations in the .161 to .373 ppm range were generated using a Meloy Model CN 020 nitrogen oxides/ozone calibrator.

Meteorological Parameters - Calibration curves supplied by the manufacturer were used to convert sensor output signals to appropriate temperature and relative humidity readings.

Particulate Measurements - The condensation nuclei counter was not calibrated. It was used to indicate relative differences in condensation nuclei and not as a absolute measurement device. The integrating nephelometer was spanned using the standard Fluorocarbon technique.

TABLE A-5. OZONE AND OXIDES OF NITROGEN CALIBRATION RESULTS.

Parameter	Method	Date	Concentration (ppb) Input	Concentration (ppb) Measured
NO/NO_x	Gas phase dilution Meloy CN020	7/12/81	.373	.379/.381
			.330	.330/.338
			.246	.240/.245
			.196	.191/.195
			.161	.161/.165
O_3	Transfer std. MEC 1000 O_3 Generator	7/9/81	23	23
			71	71
			87	89
			115	117
			160	169
		7/18/81	23	24
			56	55
			87	89
			115	117
			160	168
		7/24/81	23	21
			56	56
			71	72
			115	120
			160	170
		7/28/81	23	21
			71	67
			87	82
			115	111
			160	164

DATA PROCESSING

All data collected in the aircraft were recorded on 4-track magnetic tape using a Metrodata Model DL 620A data logging system. Instrument and sensor responses were recorded five times every two seconds in the aircraft. Under normal flying conditions this corresponds to a data point approximately every 90 feet. Following completion of the field work, data on the 4-track tapes were transferred to 9-track tapes for further processing. Table A-6 lists the equations employed to convert raw voltages to scientific units for the various parameters.

TABLE A-6. DATA PROCESSING EQUATIONS

Parameter	Equation
Altitude (10's of feet)	ALT = V (3500) + 100 (Baro. Pres. - 29.22)
Temperature(°C)	TMP = 320.5 x Tan[2(V - 0.50)]
Ozone (ppb)	$O_3 = V(\text{Inst. Range})$
O_3 (ALT Corr'd)	$O_3' = O_3 \dfrac{124.5(\text{Calibration Pressure})}{3555.5 - \text{Altitude}}$ if ALT ≥ 633* $O_3' = O_3 \dfrac{99.1\ (\text{Calibration Pressure})}{2955.3 - \text{Altitude}}$ if ALT < 633*
NO/NO_x (ppb)	$NO/NO_x = V\ (\text{Inst. Range})$
Visual Range (km)	$B_{scat} = V(\text{Inst. Range})$ $VR = 3900/B_{scat}$
Relative Humidity (%)	$RH = 3.321(100\ V)^{0.76} - 6.56 + 0.40(\text{Temperature})$
Condensation Nuclei (cm^{-3})	CN = V(Inst. Range)

V = Voltage
* 10's of feet

DATA VALIDATION

The aircraft data system operated throughout the study period without failure. As indicated previously, voltage outputs from the various instruments and sensors were recorded on magnetic tape in the field and then transferred to 9-track tapes at our home laboratory. The data was then converted to scientific units using the appropriate equations shown in Table A-6.

A continuous record of ozone concentrations was also obtained on a strip chart recorder in the aircraft. A second channel on the strip chart recorder was utilized to acquire a real time record of a second parameter. Normally this was NO_x; however, at various times this continuous record was switched between temperature, CN and nephelometer readings.

Data validity screening was accomplished entirely by manual methods. Instrument operator notes were used to determine times at which instrument range changes, zero checks and span checks were made. Whenever possible, tape recorded data was compared with strip chart data. Since ozone data were continuously recorded by both mechanisms, data validity could be double checked for that parameter.

Any rapid increases or decreases for a particular parameter were examined carefully to see if there was a logical reason for the change. For example, a sharp decrease in ozone was compared with the same NO_x time profile to see if there was a corresponding increase in NO or NO_2.

The only time data were removed from the record was when an instrument malfunctioned or during the short transition period between a range change. In the latter case, about 25 scans (10 sec) were eliminated when an instrument range change occurred. Data recovery was greater than 90% for all parameters. It should be emphasized, however, that condensation nuclei data should not be used on an absolute basis. It is extremely difficult to calibrate the CN counter and our intended purpose for including this instrument was solely as a gross indicator of plume boundaries.

The aircraft flight path was reconstructed based on flight notes recorded by the pilot and onboard instrument technician. Major turn points shown on flight maps are based on a VOR and DME location recorded by the pilot. Location between turn points was established from VOR and DME readings as well as from visual landmarks (cities, rivers, highways, etc.). Uncertainty in location is estimated to be at most two miles.

SECTION 3

GROUND STATION SAMPLING PROGRAM

SITE DESCRIPTION

Four primary sampling sites were utilized in the Atlanta metropolitan area. Washington State University operated an air quality monitoring laboratory at the DeKalb-Peachtree airport. EPA established a monitoring station on the Georgia Tech campus which is just north and west of the urban core. The Fulton County Health Department site which is operated by the State of Georgia provided air quality data representative of the downtown Atlanta area. The fourth monitoring site was situated southeast of Atlanta on the DeKalb Community College campus. This latter station is part of the nationwide NAMS (National Air Monitoring System) network. Figure A-4 shows the location of these stations.

The two special studies laboratories (DeKalb-Peachtree and Georgia Tech) consisted of mobile trailers that had been converted to sampling platforms. Each was situated in an open area at the respective sites. The DeKalb-Peachtree monitoring station was located in the northwest corner of the airport grounds well away from the generally upwind of major airport activities. The Georgia Tech trailer was situated on an athletic field near the western edge of campus.

FIELD LABORATORIES

WSU

A 23-ft custom-built travel trailer served as the WSU field headquarters

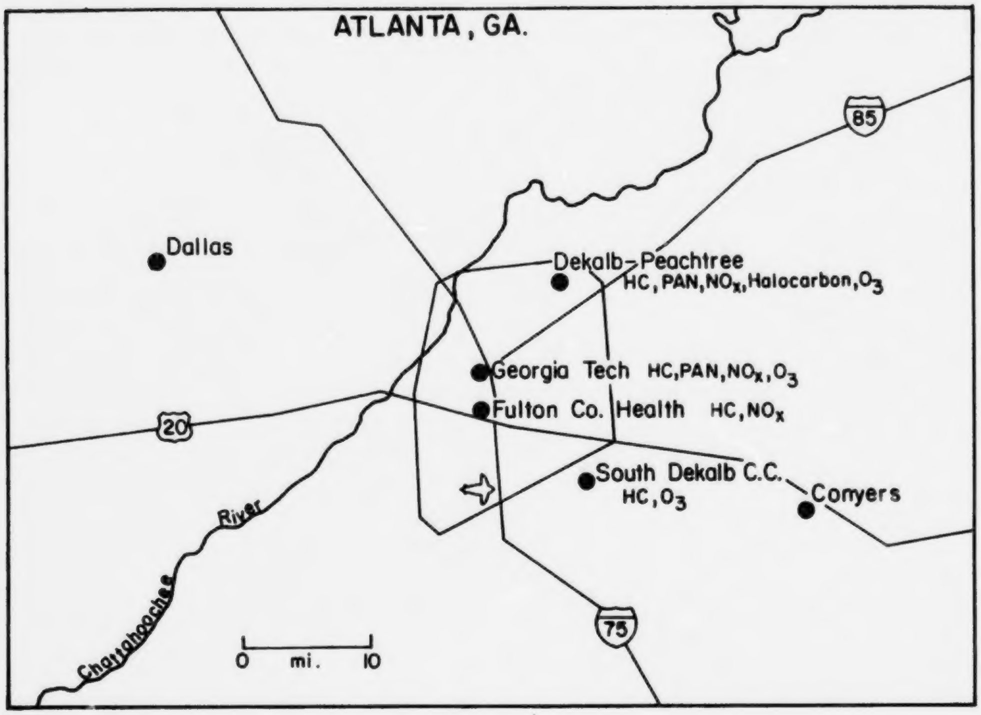


Figure A4. Location of ground level monitoring sites in Atlanta.

in Atlanta. The laboratory contains 52 ft of bench and rack space for accommodation of the monitoring instruments, meteorological sensors and data acquisition and reduction system. Most of this equipment is permanently mounted in the trailer for easy transport from site to site. The laboratory can be set up with most instruments fully operational in one day. Constant temperature within the trailer is maintained by two large air conditioners mounted on the roof.

Outside air is brought into the trailer through a 4-in. stainless steel line. The top of the air inlet stack is about 20 ft above ground level. This sample line runs the full interior length of the trailer and serves as a manifold for supplying the outside air to the continuously monitoring instruments. An air flow rate through the line of approximately 100 cfm is maintained by a squirrel-cage fan at the exhaust end. Equipment is laid out within the trailer such that those instruments monitoring the reactive gases (ozone and nitric oxide) are closest to the inlet of the manifold.

EPA

A thirty-five foot Carpenter bus was used for the ground level sampling program at Georgia Tech University. The bus was located on the western side of the campus. The laboratory was custom built and contained 55 ft of bench and rack space to accommodate air monitoring instrumentation and data acquisition systems. The instruments are mounted to the benches and racks to permit ready movement of this motorized vehicle to other sites. The laboratory is fully capable of being operational within 24 hours after setup. A central heat pump system is used to maintain the laboratory environment.

Outside air is brought into the bus through a 2-inch glass inlet line mounted 3 feet above the bus roof and approximately 15 feet above ground level. The glass inlet line is connected to an 8 port glass manifold located inside the laboratory. A sample air flow rate of approximately 100 cfm is maintained though the manifold with a squirrel-cage fan at the exhaust end. The manifold is located in the laboratory to be near those instruments monitoring the reactive gases (nitrogen oxides, ozone, and PAN).

AIR QUALITY INSTRUMENTATION

WSU

The instrumentation employed at the ground level monitoring site is summarized in Table A-7.

TABLE A-7. GROUND LEVEL AIR QUALITY INSTRUMENTATION

Parameter	Instrument (S/N)	Analysis Technique	Ranges	Resolution
Ozone	Bendix 8002 (35020-1)	Chemilum	0-200(a)	~5(a)
NO/NO_x	ML 8440 (587)	Chemilum	0-200(a)	~5(a)
Halocarbons	HP 5700A (1341A02226)	GC-EC	-	-
Temperature	Climet 016-2 (73-053)	Thermister	-5 to 45(b)	0.2(b)
Dew Point	Climet 016-2 (73-053)		-46 to 71(b)	0.2(b)
Wind Speed	Climet 011-2B (73-053)	Cup anemometer	0-100(c)	0.25(c)
Wind Direction	Climet 012-2C (73-053)	Vane	0-360(d)	0.5(d)
Radiation	Climet 0503 (73-053)	Pyranometer	-	2.0(e)

(a) units = ppb
(b) units = °C
(c) units = mph
(d) units = degrees
(e) units = cal cm^{-2} min^{-1}

EPA

The instrumentation employed at the EPA ground level site is summarized in Table A-7A.

TABLE A-7A. EPA GROUND LEVEL AIR QUALITY INSTRUMENTATION

Parameter	Instrument EPA #	Analysis Technique	Ranges	Resolution
Ozone	Bendix 8002 (083979)	Chemilum	0-200(a)	~ 5(a)
NO/NO_x	ML 8440 (153969)	Chemilum	0-200(a)	~ 5(a)
PAN		GC-EC	--	--
Visibility	MRI 1550 (090831)	Nephel.	.3-00 mi.	.3 mi
UV Radiation	Epply (033057)	Photometer	0-10 (b)	0.01 (b)

(a) ppb
(b) milliwatts per centimeter squared minutes (mw cm^{-2} min^{-1})

DATA PROCESSING

WSU

All data collected at the ground level monitoring site were recorded with a Hewlett Packard 3054A Automatic Data Acquisition/Control System. This computer based system permits in-field (real-time) conversion of output voltages to the desired scientific units, time averaging, tabulation, plotting and permanent storage of data on cassette tape cartridges. All instrument and sensor responses were recorded at one minute intervals except for the halocarbon measurements. Halocarbon levels were recorded every 30 minutes. Table A-8 lists the equations used to convert raw voltages to scientific units for the various parameters.

TABLE A-8. DATA PROCESSING EQUATIONS FOR GROUND LEVEL INSTRUMENTATION

Parameter	Equation
Ozone (ppb)	O_3 = V (Inst. Range)
NO/NO_x (ppb)	NO/NO_x = V (Inst. Range)
Temperature (°C)	TMP = V(10.0) - 5.0
Dew Point (°C)	DWP = V(10.0) - 5.0
Wind Speed (mph)	W/S = V(2.235)
Wind Direction (deg)	W/D = V(108) when $V \leq 3.33$ (V-3.33) 108 when $V > 3.33$
Radiation (Ly)	RAD = V(0.4)
Halocarbons (ppt)	Conc = Peak Height x Calib. Factor

V = Voltage

EPA

All continuous data collected at the ground level monitoring site were recorded with a Monitor Labs 9350 (EPA 154182) data acquisition system. This system recorded voltage signals from the pollutant monitoring instruments every 10 seconds and averaged the signal over selected time intervals. Thirty minute average intervals were used for this study. The averaged signals were converted to engineering units and printed out on 2 1/4 inch paper tape. The 30 minute pollutant averages were checked and stored on computer compatible tape at the RTP, NC facility.

PAN samples were taken every 30 minutes and recorded on recorder chart paper. Peak height of the PAN peaks was measured manually and converted to concentration by multiplication with a standard factor. The calculated concentrations were checked and stored on computer compatible tape at the RTP, NC facility.

Table A-8A lists equations used to convert raw voltages to scientific units for the various parameters.

TABLE A-8A. DATA PROCESSING EQUATIONS FOR EPA GROUND LEVEL INSTRUMENTATION

Parameter	Equation
Ozone (ppb)	O_3 = V* (449) - 2.8
NO (ppb)	NO = V (463) - 3.5
NO_2 (ppb)	NO_2 = V (480) + 17.1
NO_x (ppb)	NO_x = V (481) - 2.1
PAN (ppb)	PAN - peak height (0.138)
Visibility (b_{scat})	Vis - V (2.189) - 0.033
UV Radiation (mw cm^{-2} min^{-1})	UV = V (0.98)

* V = Voltage

CALIBRATION PROCEDURES

WSU

A summary of the calibration procedures and frequency for each ground level air quality monitor is outlined below.

Ozone - A multipoint calibration was performed on the Bendix 8002 ozone analyzer at the start of the study period. A MEC 1000 ozone generator was utilized to provide known concentrations in the 0-200 ppb range. Ozone generator output was verified by UV measurements (Dasibi) and the NBKI method. Span checks were performed on a regular basis throughout the field sampling period. Results from the calibration conducted on July 12 are shown in Table A-9 and the span data is listed in Table A-10.

Oxides of Nitrogen - The Monitor Labs 8440 analyzer was calibrated with a Meloy Model CN020 nitrogen oxides/ozone calibrator. The calibration source was 52 ppm NO in N_2 obtained from AIRCO (Spectra Seal cylinder #CC 444). The results of calibration and span checks are listed in Tables A-4 and A-5.

TABLE A-9. BENDIX 8002 OZONE MONITOR CALIBRATION RESULTS

Date	Concentration (ppb) input	Concentration (ppb) measured
7/21/81	23	21
	71	70
	87	86
	115	114
	160	162

Table A-10. BENDIX 8002 OZONE MONITOR SPAN DATA

Date	Response (ppb)	Date	Response (ppb)
7/13/81	168	7/21/81	172
7/14/81	167	7/22/81	177
7/15/81	171	7/25/81	169
7/16/81	169	7/28/81	171
7/17/81	162	7/31/81	181
7/20/81	172		

Mean value:	171
Standard Deviation:	5.0
% Standard Deviation:	2.9

Halocarbons - A Hewlett Packard Model 5700A Gas Chromatograph equipped with a constant-current ^{63}Ni electron capture detector was used to monitor ambient levels of fluorocarbon-11, chloroform, fluorocarbon-113, methylchloroform, carbon tetrachloride and trichloroethane. Separation was achieved on a 10-ft x 1/4-in O.D. stainless steel column containing 10% SF-96 on Chromosorb W. The column was maintained at 55°C. With a carrier gas (Nitrogen) flow of 60 ml/min, two analyses could be run each hour. This instrument was automated by attaching a 5-ml sample loop, Carle Microvalve (#5518), a Carle Valve Actuator (#4201) and a Carle Valve Minder (#4101). The electron capture gas chromatograph was calibrated with ambient air standards. At the present time, we feel this is the best method since the moisture and oxygen content of the standard will be nearly the same as in samples collected during routine analysis periods. The calibration was based on halocarbon standards that had been certified by mass spectrometry. Samples from this standard were run nearly every day throughout the study period in order to monitor stability of the electron capture detector. Table A-11 shows calibration results and precision information for fluorocarbon-11, methyl chloroform and carbon tetrachloride.

Temperature, Dew Point and Solar Radiation - Calibration curves supplied by the manufacturer (Climet) were used to convert sensor output signals to the appropriate meteorological readings.

TABLE A-11. HALOCARBON SPAN RESULTS

Date	Response (peak height) F-11	CH_3CCl_3	CCl_4
7/13	67	9.0	16
7/13	68	7.0	15
7/14	70	8.0	16
7/14	71	8.0	16
7/15	72	8.0	16
7/16	72	9.0	16
7/16	72	9.0	17
7/17	78	8.0	17
7/17	78	8.0	17
7/18	85	8.5	18
7/18	84	9.0	18
7/20	73	9.0	16
7/21	74	8.0	16
7/21	75	8.0	17
7/22	74	8.0	16
7/22	73	8.0	16
7/23	74	8.0	16
7/23	74	8.0	16
7/24	73	7.0	14
7/24	75	8.0	16
7/25	71	8.0	15
7/25	74	8.0	16
7/27	75	7.0	16
7/27	74	9.0	16
7/29	74	7.0	15
7/29	75	8.0	15
7/31	74	9.0	17
7/31	74	8.5	16
Mean value:	74	8.1	16
Standard Deviation:	3.8	0.6	0.9
% Standard Deviation:	5.1	7.8	5.4

EPA

A summary of the calibration procedures and frequency for each ground level air quality monitor is outlined below.

Ozone - A multipoint calibration of the EPA Bendix ozone monitor (EPA 083979) was performed early in the study. A TECO 101 Dynamic calibrator (EPA 070728) was used to provide ozone concentrations, with a Dasibi UV photometer (EPA 008782) for verification. Span and zero checks were performed at regular intervals throughout the study. EPA calibration data are given in Table A-12, span data are listed in Table A-12A.

TABLE A-12. CALIBRATION RESULTS FOR EPA O_3 MONITOR

Date	Concentration (ppb)	
	Input	Measured
7/17/81	18	10
	53	35
	131	118
	231	213
	330	312
	389	371

TABLE A-12A. SPAN RESULTS FOR EPA O_3 MONITOR

Date	Response
7/17/81	213 ppb
7/24/81	219
7/26/81	226
7/30/81	219
8/2/81	215

Mean Value: 218.4
Standard Deviation: 4.5

Oxides of Nitrogen - The EPA Monitor Labs analyzer was calibrated using a TECO 101 Dynamic calibrator (EPA 070728) to assure precision dilutions of the standard to concentrations of .2 - 4.0 ppm NO_x. The reference standard was supplied by Airco in a pressurized cylinder (Cylinder No. FF 3375) containing 53.9 ppm NO in nitrogen. The concentration was certified by the EPA Quality Assurance Branch, EMSL, one month before the study began. The results of calibration and span checks are listed in Tables A-13 and A-13A.

TABLE A-13. CALIBRATION RESULTS FOR EPA NO_x MONITOR

Parameter	Date	Concentration (ppb) Input	Concentration (ppb) Measured
NO/NO_x	7/12/81	3609	3588/3662
		2166	2104/2149
		1627	1536/1568
		580	497/506
		276.	225./228
NO/NO_x	7/31/81	588	589/604
		280	283/287
		0	1/2

TABLE A-13A. NO/NO_x SPAN DATA FOR EPA NO_x MONITOR

Date	Response (ppb) NO	Response (ppb) NO_x
7/19/81	319	306
7/20/81	339	315
7/24/81	360	316
7/26/81	359	325
7/31/81	375	316
8/2/81	356	316
	$\overline{x}$ = 351	$\overline{x}$ = 316
	Std. Dev. = 18	Std. Dev. = 5

PAN - Peroxyacetyl nitrate measurements were performed with GC-ECD. The PAN GC procedure consists of a 90 cm x 3.2 mm o.d. glass column packed with 10% Carbowax 600 on 60-80 mesh Gas Chrom Z. A 1-Ci tritiated scandium constant-current electron capture detector (Analog Technology Corporation, Pasadena, CA) was used in these experiments. Methane-argon (P-5 mixture, Linde Division, Union Carbide, Somerset, NJ) was used as the carrier gas and detector sensitizing gas. The column flow rate was maintained at 70 cm^3/min. Both column and detector were operated at room temperature, 23-25°C. Occasionally, the detector was heated overnight at 160°C to recondition detector surfaces and improve sensitivity. Calibrations of the GC system were performed by the analyses of an air-diluted mixture of a PAN standard. Measured aliquots of the PAN standard were injected into metered volumes of zero-grade air. Sample injections of 5 cm^3 were made onto the GC system with an automated valve. The PAN standard was prepared from the photodissociation of chlorine in the presence of acetaldehyde and NO_2. The prepared standards were calibrated with IR techniques. The PAN standard used in this study was 12.6 ppm. Results for PAN calibration are given in Table A-14.

TABLE A-14. PEAK HEIGHT AND RESPONSE FACTOR RESULTS FOR PAN CALIBRATION

Date	Concentration	Peak Heights	Factor
7/31	6.0 ppb	41.5, 43.0, 41.5 mm	0.143
	4.5 ppb	35.0, 34.0, 32.0 mm	0.134
	2.1 ppb	16.0, 15.5, 14.5 mm	0.137
		Avg.	0.138
		Standard Deviation ±	0.004

Visibility - The MRI integrating nephelometer (EPA 090831) was calibrated with Freon 12 according to the instructions outlined in the manual.

UV Radiation - The Eppley UV radiometer (EPA 033957) was used to measure sunlight radiation in the range between 3000 to 3900 Å. A calibration factor provided by the manufacture was used to convert voltage output to useful engineering units.

DATA VALIDATION

Voltage outputs from the various instruments and sensors were converted to scientific units using the appropriate equations shown in Table A-8 and A-8A. Data validity screening was accomplished by manual methods. A detailed record of range changes, zero checks and calibration times was kept during the field program. Hourly average values were obtained by averaging the 60 one-minute readings during the previous hour. Table A-15 and A-15A provide summaries of the percentage of data recovery for each parameter for the study period. Data loss was primarily due to power outages at the sampling sites.

TABLE A-15. DATA RECOVERY (%) FOR MEASUREMENTS AT WSU GROUND SITES.*

O_3	NO	NO_2	NO_x	Halocarbons	W/S	W/D	TMP	DP	RAD
87	93	93	93	87	93	93	93	93	93

* Sampling period: July 13 - August 2 (504 hours) with the exception of the oxides of nitrogen analyzer which was operated from July 13 to 10 am on July 18 (121 hours).

TABLE A-15A. DATA RECOVERY (%) FOR MEASUREMENTS AT EPA GROUND SITE.*

O_3	NO	NO_2	NO_x	PAN	Visibility	RAD
98	95	95	95	95	98	98

* Sampling period: July 11 - August 4 (576 hours)

SECTION 4

HYDROCARBON SAMPLING

Samples for individual hydrocarbon analysis were collected at four ground stations in the Atlanta area. The sampling procedure consisted of pumping ambient air from the station's manifold into Tedlar or Teflon bags. Integrated samples covering the 6-9 a.m. and 11-2 p.m. time periods were collected on most days during the study period. Washington State University collected and analyzed all samples at the DeKalb-Peachtree site. The EPA laboratory was responsible for hydrocarbon analysis at the Georgia Tech, Fulton County Health Dept and DeKalb Community College sites.

Hydrocarbon samples collected during aircraft missions were analyzed by Washington State University. Stainless steel canisters were used to collect hydrocarbon samples in the aircraft. These canisters have had their inner surfaces deactivated by the "Summa" process. The cans were filled with air using a metal bellows pump and sealed by closing two bellows valves. By pressurizing these containers to 10 psig, about 5 liters of air can be obtained for sampling purposes.

The canisters are flushed and filled to a small positive pressure with clean air or an inert gas such as nitrogen prior to an aircraft sampling mission. Actual sample collection is accomplished by flushing (~30 l/min) with the air to be sampled and then pressurizing the cans over about a twenty second period. Using this procedure, the sample containers are always under a positive pressure and contamination problems due to leakage into the vessel are minimized.

Several similarities existed in the analytical systems and procedures utilized by the two laboratories. Both of the research groups employed commercial GC systems equipped with flame ionization detectors, a computerized data acquisition system and a cryogenic concentration step. GC column types constituted the main procedural difference. EPA utilized a three column system for resolving the C_2-C_{10} hydrocarbon fraction while WSU employed only two columns. Table A-16 summarizes the GC conditions employed by the two research groups.

TABLE A-16. SUMMARY OF GC CONDITIONS UTILIZED BY THE TWO RESEARCH GROUPS

Hydrocarbons	Column	Oven Temp.
EPA		
C_2-C_5 (ex. C_4-C_5 olefins)	packed (silica gel)	25°C (isothermal)
C_4-C_8 (non-aromatic)	SCOT (dibutylmaleate)	~0°C (isothermal)
C_6-C_{10} (aromatic)	SCOT (m-bis-m-phenoxybenzene)	80°C (80°-110°C @ 10°/min)
WSU		
C_2-C_5	packed capillary (n-octane/Porasil C)	-60° to 80°C @ 24°/min
C_5-C_{10}	glass capillary (SE-30)	-50° to 80°C @ 4°/min

GAS CHROMATOGRAPHIC ANALYSIS

EPA.

Three chromatographic columns were used to analyze the C_2-C_{10} hydrocarbons.

The C_2-C_5 hydrocarbons (excluding the C_4 and C_5 olefins) were separated on a 2.4 m x 3 mm stainless steel column packed with 60/80 mesh silica gel grade 58 (Grace Laboratories, Baltimore, Maryland). The column was maintained at room temperature 25° ± 2°C with a helium carrier gas flowrate of 40 cm^3/min. The C_4-C_8 aliphatic hydrocarbons were separated on a 15.2 m x 0.51 mm i.d. SCOT column coated with dibutylmaleate. This column was maintained at ice water temperature. The helium carrier gas flowrate was 8 cm^3/min.

A 30.5 m x 0.51 mm i.d. SCOT column coated with m-bis-m-phenoxybenzene was used to separate the C_6-C_{10} aromatic hydrocarbons. The column was initially maintained at 80°C for 20 min. and then temperature programmed to 110°C at 10°C/min. during the final stages of the analysis. The carrier gas flowrate was maintained at 8 cm^3/min.

WSU.

Gas chromatographic analyses were performed with Perkin Elmer chromatographs equipped with subambient temperature programming capabilities. The column used to separate light hydrocarbons (C_2-C_6) was a packed capillary (20' x 1/16") containing Durapak n-Octane/Porasil C. When operated with a carrier gas (He) flow of 5 cm^3/min and temperature programmed from -60° to 80°C at 24°/min, this column provided excellent resolution of the light hydrocarbon fraction. A SE-30 glass capillary column (J & W Scientific) was used to separate hydrocarbons in the C_5 to C_{10} molecular weight range. Helium was used as the carrier gas with column flow maintained at 1 cm^3/min. Optimum results were obtained by temperature programming from -50° to 80°C at 4°/min.

GC CALIBRATION

Procedures employed by the two research groups for calibrating their gas chromatographs are described in the following paragraphs.

The EPA group utilized a mixture of hydrocarbons as their absolute standard. The standard was prepared by injecting a measured volume of each liquid hydrocarbon into a known volume of air. The gaseous hydrocarbon concentration was then calculated using the ideal gas law. Additional dilutions were then made until the hydrocarbon concentration approached the range normally encountered in ambient air (~30 ppbC). The mixture containing hydrocarbons of known concentration was then run on each of the three GC systems employed by EPA. Area response per ppbC factors were calculated for each hydrocarbon and then the response factors were averaged to give one factor for converting area response to concentration units. This mixture usually contained 12-15 selected C_2-C_9 hydrocarbons to permit at least 5 chromatographic peaks on each GC column. Using this procedure, individual hydrocarbon species in ambient samples are reported in units of ppbC.

Washington State University calibrated with a 0.204 ppm 2,2-dimethylbutane (neohexane) standard purchased from Scott Environmental Technology, Inc. The 0.204 ppm concentration was verified in the WSU laboratory through comparison with n-hexane standards prepared by a static dilution method similar to the procedure utilized by EPA to prepare their absolute calibration standard. The 2,2-dimethylbutane is compatible with both columns used by WSU for their hydrocarbon analyses. Measured volumes of the standard were injected into the gas chromatograph. From the recorded area responses, a graph was constructed which related area counts to weight of 2,2-dimethylbutane injected. An area count per nanogram factor was determined which was used to convert peak areas in an ambient air chromatogram to nanograms of hydrocarbon. Since the volume of sample air is carefully measured, the concentration of each hydrocarbon can be calculated in units of $\mu g/m^3$. Concentrations in ppbC units were obtained by multiplying $\mu g/m^3$ by 1.5.

The .204 ppm neohexane standard was run on each chromatograph several times during the study period. If the area counts for a 200 ml injection of this external standard varied more than 10% from the previous run, ambient sample analysis was discontinued until the reason for the variance was determined. The coefficient of variance for neohexane runs on each GC system during the study period was less than 6% (see Table A-17).

It is obvious from the foregoing discussion of calibration techniques that neither of the research groups attempted to determine response factors for each of the hydrocarbon species present in ambient atmospheres. Consequently, the assumption must be made that relative sensitivities are the same for all hydrocarbons. This is not absolutely true but the work of Dietz [2] has shown that relative responses for the majority of species that contain only carbon and hydrogen vary by only about 5%. Thus, the assumption is made that the flame ionization detector response for a fixed amount of hydrocarbon is the same for all species. Needless to say, it would be impractical to try to determine individual response factors for the one hundred or so peaks that are normally recorded in an urban air sample.

Hydrocarbon audits were not conducted during the study period. However, a number of samples were exchanged between the WSU and EPA field laboratories for the purpose of comparing hydrocarbon analytical results. Two types of hydrocarbon samples were utilized in the interlaboratory exchange program - a laboratory prepared mixture and actual ambient samples collected at Atlanta

TABLE A-17. GC RESPONSE OBTAINED FOR 200 ml INJECTION OF 0.204 ppm NEOHEXANE STANDARD

C_2-C_5 Hydrocarbon GC		C_5-C_{10} Hydrocarbon GC	
Date	Area Counts	Date	Area Counts
7/14	356270	7/15	349459
7/14	371885	7/16	339759
7/14	370627	7/17	315411
7/15	365135	7/17	365859
7/16	379759	7/22	365857
7/16	370631	7/22	361319
7/17	307379	7/22	386532
7/17	350848	7/22	331592
7/22	333062	7/23	342734
7/22	377003	7/25	326073
7/22	396098	7/25	339776
7/22	365597	7/27	369604
7/23	355637	7/27	364254
7/23	353794	7/29	331028
7/23	339827	7/29	344848
7/25	338415	7/30	339551
7/25	365214	7/30	346484
7/25	369890	7/30	356317
7/27	378241		
7/27	370988		
7/30	386061		
7/30	370972		
Mean	360606	Mean	348692
SD	19904	SD	17889
%SD (SD/Mean)	5.5	%SD (SD/Mean)	5.1

monitoring stations. The synthetic standard, which was prepared by EPA, contained a mixture of paraffinic, olefinic and aromatic hydrocarbons at concentrations commonly encountered in urban atmospheres. Tables A-18 and A-19 show analytical results obtained by each group for the synthetic standard. With the exception of the three aromatic compounds (toluene, m-xylene and 1,3,5-trimethylbenzene) the mean values obtained by WSU agree closely (±18%) with the concentration reported by EPA. The mean concentration of aromatic hydrocarbons reported by WSU varied from 27 to 44% less than that recorded by EPA.

Analytical results obtained from five ambient samples that were run by both laboratories are listed in Tables A-20-24. For most species, the values reported by WSU and EPA are agreeable. When significant differences exist it is generally due to much higher ethylene and benzene concentrations reported by EPA. This is evident in Table A-22 which shows analytical results from a sample collected at the DeKalb Community College site on July 27, 1981. EPA reported an ethylene concentration of 53.9 ppbC compared to the WSU value of 16.6 ppbC and a benzene concentration of 45.1 ppbC while WSU measured a benzene level of 4.7 ppbC.

TABLE A-18 INDIVIDUAL HYDROCARBON CONCENTRATIONS (ppbC) MEASURED BY WASHINGTON STATE UNIVERSITY IN EPA STANDARD MIX #3.

	Date Analyzed						
	7/15	7/20	7/24	7/27	7/31	Mean	SD
Ethane	14.0	15.6	15.5	14.5	13.2	14.6	1.0
i-Butane	18.4	18.1	18.1	18.6	18.4	18.3	0.2
n-Butane	16.3	16.4	14.2	15.1	14.9	15.4	0.9
n-Hexane	14.7	-	14.5	14.3	-	14.5	0.2
2,4-Dimethylpentane	16.2	-	16.6	16.2	-	16.3	0.2
Cyclohexane	20.5	-	24.1	23.9	-	22.8	2.0
3-Methylhexane	12.3	-	12.7	13.1	-	12.7	0.4
Propene	18.8	18.7	18.8	19.4	19.0	18.9	0.3
i-Butene	19.7	19.5	20.2	20.5	20.4	20.1	0.4
t-2-Butene	5.7	5.7	5.6	6.0	5.5	5.7	0.2
Tolene	17.1	-	13.5	15.0	-	15.2	1.8
m & p-Xylene	14.8	-	7.7	10.9	-	11.1	3.6
1,3,5-Trimethylbenzene	9.1	-	6.6	5.2	-	7.0	2.0

TABLE A-19. INDIVIDUAL HYDROCARBON CONCENTRATIONS (ppbC) MEASURED BY EPA IN EPA STANDARD MIX #3.

	Date Analyzed										
	7/14	7/15	7/17	7/19	7/23	7/24	7/26	7/29	7/30	7/30	Mean	SD
Ethane	16.1	16.0	15.6	15.6	16.7	15.6	16.6	16.5	17.7	16.3	16.3	0.7
i-Butane	17.9	17.8	18.0	17.8	15.4	17.8	19.1	21.0	19.3	20.5	18.5	1.6
n-Butane	15.6	15.5	16.1	14.0	20.5	14.3	15.3	17.1	15.3	16.3	16.0	1.8
n-Hexane	15.4	15.3	15.8	16.7	17.0	15.9	17.0	21.2	17.1	17.8	16.9	1.7
2,4-Dimethylpentane	16.6	16.0	-	17.7	17.9	17.1	17.7	20.9	18.4	18.8	17.9	1.4
Cyclohexane	19.8	17.9	19.5	21.3	21.2	19.2	20.7	29.2	21.1	23.5	21.4	3.1
3-Methylhexane	15.1	14.1	14.3	15.3	15.8	14.6	15.6	18.1	16.1	16.6	15.6	1.2
Propene	15.6	16.6	16.9	17.3	18.0	17.8	17.5	24.7	18.8	17.7	18.1	2.5
i-Butene	18.6	18.4	19.0	-	-	19.3	20.4	22.5	21.2	21.7	20.1	1.5
t-2-Butene	5.6	5.5	5.9	-	-	6.0	6.2	6.9	6.4	6.6	6.1	0.5
Toluene	-	18.8	20.6	21.9	21.3	19.5	23.2	20.1	-	21.7	20.9	1.4
m & p-Xylene	-	17.0	17.7	19.9	20.2	14.8	21.5	11.6	-	19.5	17.8	3.3
1,3,5-Trimethylbenzene	-	9.5	10.3	16.3	16.2	3.5	16.4	-	-	15.9	12.6	5.0

TABLE A-20. INDIVIDUAL HYDROCARBON CONCENTRATIONS (ppbC) IN SAMPLES COLLECTED ON JULY 20 BETWEEN 1100-1400 AT DEKALB COMMUNITY COLLEGE.

		EPA	WSU
1.	ID HC	120	109
2.	Paraffins	72.5	82.7
3.	Percent Paraffins	60	76
4.	Olefins	12.8	10.7
5.	Percent Olefins	11	10
6.	Aromatics	29.8	12.3
7.	Percent Aromatics	25	11
8.	TNMHC	123	117
9.	Carbon Monoxide	*	*
10.	Methane	*	*
11.	Ethane	6.4	6.1
12.	Ethylene	4.1	2.3
13.	Acetylene	4.1	4.2
14.	Propane	5.7	6.1
15.	Propene	1.1	1.3
16.	i-Butane	5.9	5.3
17.	n-Butane	16.9	17.0
18.	1-Butene		1.1
19.	i-Butene	1.9	0.7
20.	t-2-Butene	1.2	0.9
21.	c-2-Butene	0.8	*
22.	i-Pentane	16.5	17.0
23.	n-Pentane	6.9	6.8
24.	3-Methyl-1-Butene	0.3	-
25.	1,3-Butadiene	*	*
26.	1-Pentene	0.4	-
27.	Isoprene	4.2	4.4
28.	t-2-Pentene	0.8	-
29.	c-2-Pentene	-	-
30.	2-Methyl-2-Butene	2.0	-
31.	2,2-Dimethylbutane	*	-
32.	Cyclopentene	*	-
33.	Cyclopentane	1.6	-
34.	4-Methyl-1-Pentene	-	-
35.	2,3-Dimethylbutane	*	1.0
36.	2-Methylpentane	4.4	3.3
37.	c-4-Methyl-2-Pentene	-	*
38.	3-Methylpentane	2.3	2.2
39.	2-Methyl-1-Pentene	*	*
40.	1-Hexene	0.2	-
41.	n-Hexane	2.6	2.0
42.	t-2-Hexene	*	*

TABLE A-20 continued.

43.	2-Methyl-2-Pentene	*	*
44.	c-2-Hexene	*	*
45.	Methylcyclopentane	2.2	1.4
46.	c-3-Methyl-2-Pentene	*	*
47.	2,2,3-Trimethylbutane	*	*
48.	2,4-Dimethylpentane	*	1.3
49.	Benzene	5.0	1.9
50.	1-Methylcyclopentene	*	*
51.	Cyclohexane	5.0	-
52.	2-Methylhexane	4.2	1.4
53.	2,3-Dimethylpentane	1.9	*
54.	3-Methylhexane	1.4	0.7
55.	Dimethylcyclopentane	-	*
56.	2,2,4-Trimethylpentane	1.8	1.1
57.	n-Heptane	0.8	0.6
58.	Methylcyclohexane	0.7	1.1
59.	Trimethylcyclopentane	*	*
60.	Ethylcyclopentane	*	*
61.	2,5-Dimethylhexane	*	*
62.	2,4-Dimethylhexane	*	*
63.	2,3,4-Trimethylpentane	*	*
64.	Toluene	8.5	6.4
65.	2,3-Dimethylhexane	*	0.6
66.	2-Methylheptane	*	-
67.	3-Methylheptane	*	-
68.	2,2,5-Trimethylhexane	*	-
69.	Dimethylcyclohexane	*	*
70.	n-Octane	*	0.7
71.	Ethylcyclohexane	*	*
72.	Ethylbenzene	1.6	1.4
73.	m & p-Xylene	4.2	3.4
74.	Stryene	0.7	0.9
75.	o-Xylene	1.9	1.4
76.	n-Nonane	1.4	1.2
77.	i-Propylbenzene	*	*
78.	n-Propylbenzene	0.9	*
79.	m & p-Ethyltoluene	2.4	0.8
80.	1,3,5-Trimethylbenzene	0.9	0.6
81.	o-Ethyltoluene	0.8	0.7
82.	1,2,4-Trimethylbenzene	-	*
83.	sec-Butylbenzene	-	*
84.	1,2,3-Trimethylbenzene	0.2	*
85.	n-Decane	0.8	*
86.	Methylstyrene	-	*
87.	1,3-Diethylbenzene	*	*
88.	1,4-Diethylbenzene	*	*

- means concentration was less than 0.5 ppbC
* means faulty data or no data

TABLE A-21. INDIVIDUAL HYDROCARBON CONCENTRATIONS (ppbC) IN SAMPLES COLLECTED ON JULY 22 BETWEEN 1100-1400 AT DEKALB COMMUNITY COLLEGE.

		EPA	WSU
1.	ID HC	118	67.5
2.	Paraffins	61.1	45.8
3.	Percent Paraffins	52	68
4.	Olefins	19.9	9.3
5.	Percent Olefins	17	14
6.	Aromatics	33.6	11.7
7.	Percent Aromatics	28	17
8.	TNMHC	120	77.9
9.	Carbon Monoxide	*	*
10.	Methane	*	*
11.	Ethane	3.8	3.5
12.	Ethylene	3.1	2.8
13.	Acetylene	2.5	2.2
14.	Propane	2.7	2.6
15.	Propene	0.7	1.5
16.	i-Butane	4.0	2.8
17.	n-Butane	11.1	10.4
18.	1-Butene	1.4	-
19.	i-Butene		0.5
20.	t-2-Butene	0.8	0.6
21.	c-2-Butene	2.2	*
22.	i-Pentane	12.1	9.0
23.	n-Pentane	6.0	4.9
24.	3-Methyl-1-Butene	2.2	-
25.	1,3-Butadiene	*	*
26.	1-Pentene	1.8	-
27.	Isoprene	3.0	2.6
28.	t-2-Pentene	2.5	0.6
29.	c-2-Pentene	1.5	0.7
30.	2-Methyl-2-Butene	3.5	-
31.	2,2-Dimethylbutane	*	-
32.	Cyclopentene	*	-
33.	Cyclopentane	1.1	-
34.	4-Methyl-1-Pentene	*	*
35.	2,3-Dimethylbutane	*	1.1
36.	2-Methylpentane	3.9	2.7
37.	c-4-Methyl-2-Pentene	*	*
38.	3-Methylpentane	2.4	1.7
39.	2-Methyl-1-Pentene	*	*
40.	1-Hexene	0.2	-
41.	n-Hexane	2.2	0.7
42.	t-2-Hexene	*	-

TABLE A-21 continued.

43.	2-Methyl-2-Pentene	*	*
44.	c-2-Hexene	*	*
45.	Methylcyclopentane	1.6	1.4
46.	c-3-Methyl-2-Pentene	*	*
47.	2,2,3-Trimethylbutane	*	*
48.	2,4-Dimethylpentane	*	1.1
49.	Benzene	15.8	1.5
50.	1-Methylcyclopentene	*	*
51.	Cyclohexane	5.4	-
52.	2-Methylhexane	5.4	1.7
53.	2,3-Dimethylpentane	1.3	*
54.	3-Methylhexane	0.9	0.7
55.	Dimethylcyclopentane	-	-
56.	2,2,4-Trimethylpentane	0.9	*
57.	n-Heptane	0.5	-
58.	Methylcyclohexane	0.2	-
59.	Trimethylcyclopentane	*	*
60.	Ethylcyclopentane	*	*
61.	2,5-Dimethylhexane	*	-
62.	2,4-Dimethylhexane	*	-
63.	2,3,4-Trimethylpentane	*	-
64.	Toluene	4.8	3.9
65.	2,3-Dimethylhexane		-
66.	2-Methylheptane		-
67.	3-Methylheptane		-
68.	2,2,5-Trimethylhexane		-
69.	Dimethylcyclohexane	*	*
70.	n-Octane	*	-
71.	Ethylcyclohexane	*	*
72.	Ethylbenzene	0.4	0.8
73.	m & p-Xylene	1.9	1.6
74.	Stryene	0.4	*
75.	o-Xylene	1.0	0.7
76.	n-Nonane	0.8	-
77.	i-Propylbenzene	*	-
78.	n-Propylbenzene	0.6	-
79.	m & p-Ethyltoluene	1.0	-
80.	1,3,5-Trimethylbenzene	0.7	1.3
81.	o-Ethyltoluene	0.3	1.9
82.	1,2,4-Trimethylbenzene	1.1	*
83.	sec-Butylbenzene	-	*
84.	1,2,3-Trimethylbenzene	-	*
85.	n-Decane	0.4	*
86.	Methylstyrene	-	*
87.	1,3-Diethylbenzene	*	*
88.	1,4-Diethylbenzene	*	*

- means concentration was less than 0.5 ppbC
* means faulty data or no data

TABLE A-22. INDIVIDUAL HYDROCARBON CONCENTRATIONS (ppbC) IN SAMPLES COLLECTED ON JULY 27 BETWEEN 1100-1400 AT DEKALB COMMUNITY COLLEGE.

		EPA	WSU
1.	ID HC	420	283
2.	Paraffins	210	185
3.	Percent Paraffins	50	65
4.	Olefins	82.2	37.5
5.	Percent Olefins	20	13
6.	Aromatics	118	52.9
7.	Percent Aromatics	28	19
8.	TNMHC	430	301
9.	Carbon Monoxide	*	*
10.	Methane	*	*
11.	Ethane	7.7	6.1
12.	Ethylene	53.9	16.6
13.	Acetylene	8.0	7.1
14.	Propane	10.5	10.8
15.	Propene	2.8	3.2
16.	i-Butane	9.3	9.3
17.	n-Butane	36.7	36.0
18.	1-Butene		1.6
19.	i-Butene	3.2	1.7
20.	t-2-Butene	4.3	2.3
21.	c-2-Butene	4.6	*
22.	i-Pentane	41.7	41.3
23.	n-Pentane	22.3	19.6
24.	3-Methyl-1-Butene	1.8	1.0
25.	1,3-Butadiene	*	*
26.	1-Pentene	2.3	0.8
27.	Isoprene	7.9	7.1
28.	t-2-Pentene	3.0	1.3
29.	c-2-Pentene	1.1	0.7
30.	2-Methyl-2-Butene	4.5	1.2
31.	2,2-Dimethylbutane	*	*
32.	Cyclopentene	*	*
33.	Cyclopentane	3.1	2.0
34.	4-Methyl-1-Pentene	*	*
35.	2,3-Dimethylbutane	*	2.7
36.	2-Methylpentane	13.0	10.7
37.	c-4-Methyl-2-Pentene	-	-
38.	3-Methylpentane	7.5	6.1
39.	2-Methyl-1-Pentene	*	-
40.	1-Hexene	0.7	-
41.	n-Hexane	9.3	6.6
42.	t-2-Hexene	-	-

TABLE A-22 continued.

43.	2-Methyl-2-Pentene	*	*
44.	c-2-Hexene	*	*
45.	Methylcyclopentane	6.3	4.0
46.	c-3-Methyl-2-Pentene	*	*
47.	2,2,3-Trimethylbutane	*	*
48.	2,4-Dimethylpentane	0.7	2.4
49.	Benzene	45.1	4.7
50.	1-Methylcyclopentene	*	*
51.	Cyclohexane	7.0	2.5
52.	2-Methylhexane	8.5	4.7
53.	2,3-Dimethylpentane	6.0	-
54.	3-Methylhexane	6.3	2.5
55.	Dimethylcyclopentane	3.1	0.7
56.	2,2,4-Trimethylpentane	6.3	4.9
57.	n-Heptane	3.7	2.5
58.	Methylcyclohexane	2.2	2.5
59.	Trimethylcyclopentane	*	*
60.	Ethylcyclopentane	*	*
61.	2,5-Dimethylhexane	0.6	*
62.	2,4-Dimethylhexane	*	*
63.	2,3,4-Trimethylpentane	*	*
64.	Toluene	37.3	19.7
65.	2,3-Dimethylhexane	*	2.4
66.	2-Methylheptane	*	2.3
67.	3-Methylheptane	*	0.9
68.	2,2,5-Trimethylhexane	*	*
69.	Dimethylcyclohexane	*	*
70.	n-Octane	*	1.6
71.	Ethylcyclohexane	*	*
72.	Ethylbenzene	4.8	4.3
73.	m & p-Xylene	12.3	11.2
74.	Stryene	0.6	1.4
75.	o-Xylene	5.0	4.1
76.	n-Ncnane	3.5	1.7
77.	i-Propylbenzene	*	-
78.	n-Propylbenzene	1.2	*
79.	m & p-Ethyltoluene	4.4	3.4
80.	1,3,5-Trimethylbenzene	0.8	0.9
81.	o-Ethyltoluene	1.1	1.6
82.	1,2,4-Trimethylbenzene	-	*
83.	sec-Butylbenzene	3.6	*
84.	1,2,3-Trimethylbenzene	0.8	*
85.	n-Decane	1.1	*
86.	Methylstyrene	-	*
87.	1,3-Diethylbenzene	*	*
88.	1,4-Diethylbenzene	0.5	*

- means concentration was less than 0.5 ppbC

* means faulty data or no data

TABLE A-23. INDIVIDUAL HYDROCARBON CONCENTRATIONS (ppbC) IN SAMPLES COLLECTED ON JULY 28 BETWEEN 1100-1400 AT FULTON COUNTY HEALTH DEPARTMENT.

		EPA	WSU
1.	ID HC	342	260
2.	Paraffins	197	178
3.	Percent Paraffins	58	69
4.	Olefins	44.4	24.4
5.	Percent Olefins	13	9
6.	Aromatics	95.8	58.1
7.	Percent Aromatics	28	22
8.	TNMHC	363	285
9.	Carbon Monoxide	*	*
10.	Methane	*	*
11.	Ethane	3.2	*
12.	Ethylene	11.6	*
13.	Acetylene	9.8	*
14.	Propane	3.7	*
15.	Propene	4.4	3.2
16.	i-Butane	9.3	7.0
17.	n-Butane	39.3	33.0
18.	1-Butene	5.3	1.8
19.	i-Butene		1.7
20.	t-2-Butene	2.7	2.5
21.	c-2-Butene	2.9	*
22.	i-Pentane	47.0	43.7
23.	n-Pentane	21.6	20.0
24.	3-Methyl-1-Butene	2.4	1.4
25.	1,3-Butadiene	*	*
26.	1-Pentene	1.6	1.1
27.	Isoprene	3.1	3.6
28.	t-2-Pentene	3.8	2.7
29.	c-2-Pentene	3.0	1.5
30.	2-Methyl-2-Butene	4.7	3.7
31.	2,2-Dimethylbutane	*	*
32.	Cyclopentene	*	1.2
33.	Cyclopentane	3.5	2.2
34.	4-Methyl-1-Pentene	*	*
35.	2,3-Dimethylbutane	*	3.7
36.	2-Methylpentane	14.1	11.8
37.	c-4-Methyl-2-Pentene	0.8	*
38.	3-Methylpentane	8.0	8.0
39.	2-Methyl-1-Pentene	-	-
40.	1-Hexene	1.2	-
41.	n-Hexane	8.7	7.5
42.	t-2-Hexene	-	-

TABLE A-23 continued.

43. 2-Methyl-2-Pentene	*	*
44. c-2-Hexene	*	*
45. Methylcyclopentane	7.9	5.2
46. c-3-Methyl-2-Pentene	*	*
47. 2,2,3-Trimethylbutane	*	*
48. 2,4-Dimethylpentane	0.5	3.1
49. Benzene	17.4	7.2
50. 1-Methylcyclopentene	*	*
51. Cyclohexane	6.6	3.3
52. 2-Methylhexane	4.8	7.3
53. 2,3-Dimethylpentane	4.4	*
54. 3-Methylhexane	4.3	3.1
55. Dimethylcyclopentane	1.0	1.7
56. 2,2,4-Trimethylpentane	6.9	5.1
57. n-Heptane	2.5	2.0
58. Methylcyclohexane	1.9	2.0
59. Trimethylcyclopentane	*	*
60. Ethylcyclopentane	*	*
61. 2,5-Dimethylhexane	*	*
62. 2,4-Dimethylhexane	*	*
63. 2,3,4-Trimethylpentane	*	*
64. Toluene	25.6	18.3
65. 2,3-Dimethylhexane	*	2.3
66. 2-Methylheptane	*	1.6
67. 3-Methylheptane	*	1.6
68. 2,2,5-Trimethylhexane	*	*
69. Dimethylcyclohexane	*	*
70. n-Octane	*	1.2
71. Ethylcyclohexane	*	*
72. Ethylbenzene	4.1	3.6
73. m & p-Xylene	11.8	11.3
74. Stryene	2.1	2.1
75. o-Xylene	7.3	4.6
76. n-Nonane	2.4	1.8
77. i-Propylbenzene	*	-
78. n-Propylbenzene	1.8	-
79. m & p-Ethyltoluene	7.7	6.2
80. 1,3,5-Trimethylbenzene	1.7	2.7
81. o-Ethyltoluene	1.4	0.9
82. 1,2,4-Trimethylbenzene	7.4	*
83. sec-Butylbenzene	-	*
84. 1,2,3-Trimethylbenzene	3.1	*
85. n-Decane	0.3	*
86. Methylstyrene	-	*
87. 1,3-Diethylbenzene	0.6	*
88. 1,4-Diethylbenzene	0.7	*

- means concentration was less than 0.5 ppbC

* means faulty data or no data

TABLE A-24. INDIVIDUAL HYDROCARBON CONCENTRATIONS (ppbC) IN SAMPLES COLLECTED ON AUGUST 2 BETWEEN 1100-1400 AT FULTON COUNTY HEALTH DEPARTMENT.

		EPA	WSU
1.	ID HC	241	209
2.	Paraffins	138	140
3.	Percent Paraffins	57	67
4.	Olefins	31.5	21
5.	Percent Olefins	13	10
6.	Aromatics	68.3	43
7.	Percent Aromatics	28	21
8.	TNMHC	267	230
9.	Carbon Monoxide	*	*
10.	Methane	*	*
11.	Ethane	5.3	4.6
12.	Ethylene	11.3	5.8
13.	Acetylene	8.8	8.0
14.	Propane	3.9	4.5
15.	Propene	4.0	4.4
16.	i-Butane	6.2	6.2
17.	n-Butane	23.2	23.8
18.	1-Butene	4.1	1.3
19.	i-Butene		1.9
20.	t-2-Butene	1.8	2.5
21.	c-2-Butene	2.1	*
22.	i-Pentane	29.3	30.7
23.	n-Pentane	14.8	12.9
24.	3-Methyl-1-Butene	*	1.3
25.	1,3-Butadiene	*	*
26.	1-Pentene	2.2	0.8
27.	Isoprene	2.9	3.3
28.	t-2-Pentene	2.2	1.2
29.	c-2-Pentene	0.8	0.8
30.	2-Methyl-2-Butene	1.8	2.0
31.	2,2-Dimethylbutane	*	*
32.	Cyclopentene	*	-
33.	Cyclopentane	2.6	1.5
34.	4-Methyl-1-Pentene	*	*
35.	2,3-Dimethylbutane	*	2.4
36.	2-Methylpentane	10.0	7.9
37.	c-4-Methyl-2-Pentene	0.3	*
38.	3-Methylpentane	5.6	4.8
39.	2-Methyl-1-Pentene	*	-
40.	1-Hexene	0.7	-
41.	n-Hexane	5.7	5.5
42.	t-2-Hexene	*	-

TABLE A-24 continued.

43. 2-Methyl-2-Pentene	*	-
44. c-2-Hexene	*	-
45. Methylcyclopentane	5.7	4.2
46. c-3-Methyl-2-Pentene	*	*
47. 2,2,3-Trimethylbutane	*	*
48. 2,4-Dimethylpentane	0.3	2.1
49. Benzene	13.5	5.9
50. 1-Methylcyclopentene	*	*
51. Cyclohexane	1.0	1.4
52. 2-Methylhexane	5.8	4.7
53. 2,3-Dimethylpentane	4.1	*
54. 3-Methylhexane	3.8	2.0
55. Dimethylcyclopentane	2.0	0.6
56. 2,2,4-Trimethylpentane	4.9	4.2
57. n-Heptane	1.9	1.9
58. Methylcyclohexane	0.1	1.6
59. Trimethylcyclopentane	*	*
60. Ethylcyclopentane	*	*
61. 2,5-Dimethylhexane	*	*
62. 2,4-Dimethylhexane	*	*
63. 2,3,4-Trimethylpentane	*	*
64. Toluene	19.6	14.7
65. 2,3-Dimethylhexane	*	1.3
66. 2-Methylheptane	*	1.6
67. 3-Methylheptane	*	1.1
68. 2,2,5-Trimethylhexane	*	*
69. Dimethylcyclohexane	*	*
70. n-Octane	*	0.7
71. Ethylcyclohexane	*	*
72. Ethylbenzene	2.9	2.8
73. m & p-Xylene	8.3	7.4
74. Stryene	1.0	1.7
75. o-Xylene	4.5	4.2
76. n-Nonane	*	2.1
77. i-Propylbenzene	*	*
78. n-Propylbenzene	0.8	*
79. m & p-Ethyltoluene	4.5	4.0
80. 1,3,5-Trimethylbenzene	1.1	1.3
81. o-Ethyltoluene	1.0	1.2
82. 1,2,4-Trimethylbenzene	5.1	*
83. sec-Butylbenzene	-	*
84. 1,2,3-Trimethylbenzene	0.9	*
85. n-Decane	-	*
86. Methylstyrene	-	*
87. 1,3-Diethylbenzene	-	*
88. 1,4-Diethylbenzene	1.5	*

- means concentration was less than 0.5 ppbC
* means faulty data or no data

SECTION 5

URBAN TRACER EXPERIMENTS

Near the end of the study period, three atmospheric tracer tests were conducted to tag the early morning emissions in downtown Atlanta. During each experiment, sulfur hexafluoride (SF_6) tracer was released at a constant rate for several hours from the surface at the Georgia Tech monitoring site. Air samples were collected in 20 cm^3 polyethylene syringes either manually along automobile traverses downwind of the release or via ten automatic portable syringe samplers deployed in the downwind sector. The portable samplers (D & S Instruments, Pullman, WA) were each used to collect four sequential one hour-averaged samples beginning automatically at a pre-determined time.

Samplers were typically deployed early in the morning prior to the test. The sample sites were usually roadside businesses or gas stations. All of the air samples were analyzed within 36 hours of collection at the DeKalb-Peachtree field laboratory.

TRACER RELEASE

During each tracer test, SF_6 was released from three cylinders connected via a manifold to a single gas regulator and gas rotameter. The tracer gas was released at a height of approximately 5 m. The rotameter was monitored throughout the test. Because the release rate was very steady, only very minor adjustments were occasionally required to maintain a constant flow. Average tracer release rates for the three tests were 10.5 g/s (83.3 lb/hr), 13.1 g/s (104 lb/hr), and 13.1 g/s (104.0 lb/hr). These rates were determined from the length of the release period and from the cylinder weights measured before and after each release. Given a weighing accuracy of ±0.5 lb and the time of release accurate to within ±1 min, the estimated error in the release rate is approximately ±3%.

SAMPLE ANALYSIS

Syringe samples were analyzed using two custom-built electron capture gas chromatographs (designated A3 and A4) designed specifically for SF_6 analyses. The gas chromatographs were each fitted with a 6-port gas sampling value and a 1 cm^3 gas sample loop. Tracer separation was achieved with a molecular sieve 5A 80/100 mesh packed stainless steel column (¼" O.D. x 39"). With prepurified nitrogen as the carrier gas flowing at approximately 50 cm^3/min, SF_6 eluted as a very sharp peak at 20 s followed by oxygen at approximately 60 s. The column and tritium foil detector were operated at ambient temperatures. Peak areas were determined with a Perkin-Elmer M-1 electronic integrator.

The gas chromatographs were calibrated on July 23, 1981 using an exponential dilution system which yields SF_6 concentrations ranging from approximately $3 \cdot 10^5$ to 1 ppt (3). This device has been used previously to determine the solubility of SF_6 in water for comparison to literature values based on careful volumetric-manometric measurements reported to be accurate to within less than ±1% (4). The results from Lamb and Shair agreed with the published data to within ±6% which indicates that the dilution calibration system is accurate to within approximately ±6%.

Air samples were analyzed during the period July 28 through August 3, 1981. During the analysis periods, samples from two secondary standard SF_6/air cylinders were periodically analyzed. The cylinders were prepared at WSU prior to the field study using simple static dilution techniques. The times and observed concentrations from these secondary standard analyses are listed in Table A-25. The results indicate that the reported concentrations from the two instruments were in very good agreement and that the response of the instruments changed by less than approximately 10% during the test period.

TABLE A-25. Analysis of SF_6 Standards

Date	Time (EST)	SF_6 (ppt)	
		GC(A3)	GC(A4)
Cylinder #1			
7/24	1045	540	558
	1120	510	557
	1800	534	554
7/31	0630	604	546
	0900	582	548
8/3	1300	-	529
	1800	498	503
	2000	512	497
	2200	481	-
	Mean	533	537
	Std. Deviation	±42	±24
	%SD	(±8%)	(±5%)
Cylinder #2			
7/25	1300	574	581
7/28	0830	494	563
	0833	474	558
	1400	554	553
7/29	2000	590	547
7/30	0615	629	569
	1615	575	530
8/3	1800	498	522
	2200	509	505
	Mean	544	548
	Std. Deviation	±52	±24
	%SD	(±10%)	(±4%)

REFERENCES

1. Gray, J. C., Audit Results of EKMA Monitoring In and Around Atlanta, U.S. Environmental Protection Agency - Region IV, August 27, 1981.

2. Dietz, W. A. Journal of Gas Chromatography 5:68 (1967).

3. Lamb, B. Development and Application of Dual Atmospheric Tracer Techniques for Characterization of Pollutant Transport and Dispersion. Ph.D. Thesis, California Institute of technology, Pasadena, CA 91125 (1978).

4. Lamb, B., and F. Shair, Anal. Chem. 48:473 (1976).

Appendix B

Hourly Average Air Quality and Meteorological Data Collected at the Dekalb-Peachtree Site

Preceding page blank

Table B1. Surface Data Collected At Dekalb-Peachtree Airport on 7/12/81.

	GAS DATA							MET. DATA				
Time hr	O_3 ppb	NO ppb	NO_2 ppb	NO_x ppb	$CFCl_3$ ppt	CCl_4 ppt	CH_3CCl_3 ppt	WS m/s	WD deg	TMP °C	DP °C	RAD Ly
0100												
0200												
0300												
0400												
0500												
0600												
0700												
0800												
0900												
1000												
1100												
1200												
1300												
1400												
1500												
1600												
1700												
1800	88	4	7	11				3.2	289	32.6	19.3	0.7
1900	94	5	12	16				2.5	299	31.9	19.3	0.4
2000	90	4	13	16				1.9	273	31.4	19.6	0.1
2100	65	4	24	26				1.2	263	30.4	20.1	0
2200	44	4	23	25				1.2	240	29.4	20.3	0
2300	31	3	26	28				1.0	234	28.7	20.4	0
2400	24	3	31	32				1.0	259	28.1	20.3	0

Table B2. Surface Data Collected At Dekalb-Peachtree Airport on 7/13/81.

			GAS DATA						MET. DATA			
Time hr	O_3 ppb	NO ppb	NO_2 ppb	NO_x ppb	$CFCl_3$ ppt	CCl_4 ppt	CH_3CCl_3 ppt	WS m/s	WD deg	TMP °C	DP °C	RAD Ly
0100	13	4	38	40	261	141	420	0.6	244	26.4	20.8	0
0200	14	3	29	30	275	131	2089	0.5	263	26.5	20.9	0
0300	10	3	31	32	348	136	*	0.5	300	26.1	21.0	0
0400	8	3	27	28	327	146	2129	0.4	249	25.1	21.1	0
0500	5	4	27	29	392	146	3308	0.4	293	25.0	21.0	0
0600	4	3	26	28	347	146	690	0.4	229	24.1	20.8	0
0700	6	6	29	34	263	131	*	0.6	272	24.5	20.7	0
0800	2	25	37	60	313	141	1699	0.7	260	24.5	20.9	0.1
0900	6	24	39	61	251	151	1429	1.6	282	26.2	21.3	0.3
1000	29	10	27	38	278	141	1129	2.4	289	28.2	21.7	0.6
1100	63	6	15	20	206	146	350	3.2	292	30.1	21.8	0.9
1200	73	6	11	15	203	151	170	4.2	300	31.0	21.1	1.1
1300	63	5	9	13	221	141	180	3.8	302	31.6	20.8	1.1
1400	65	5	8	12	232	146	490	4.0	298	32.4	19,8	1.3
1500	67	5	9	12	221	166	650	3.9	292	32.6	19.7	1.0
1600	71	5	11	15	231	136	*	4.1	290	33.2	19,2	1.0
1700	75	6	13	18	237	141	280	3.5	298	32.7	19.8	0.8
1800	74	7	25	31	286	151	540	2.7	300	31.9	20.0	0.3
1900	91	4	16	10	235	171	300	2.7	300	32.3	19.0	0.4
2000	77	4	17	20	232	151	350	2.1	309	31.7	17.6	0.2
2100	52	4	35	36	303	141	*	1.6	299	30.4	17.3	0
2200	33	4	46	48	341	141	*	1.4	292	29.1	17.0	0
2300	9	9	62	67	503	146	*	0.7	304	27.5	17.6	0
2400	3	8	61	66	*	146	4367	0.5	264	25.9	18.1	0

Table B3. Surface Data Collected At Dekalb-Peachtree Airport on 7/14/81.

	GAS DATA							MET. DATA				
Time	O_3	NO	NO_2	NO_x	$CFCl_3$	CCl_4	CH_3CCl_3	WS	WD	TMP	DP	RAD
hr	ppb	ppb	ppb	ppb	ppt	ppt	ppt	m/s	deg	°C	°C	Ly
0100	12	4	49	50	493	141	*	0 .5	304	25.9	18.0	0
0200	11	3	44	45	456	151	3248	0 .5	299	24.9	18.1	0
0300	32	5	34	36	402	146	630	1.2	309	25.2	18.3	0
0400	57	3	13	17	259	136	1789	2.0	289	25.0	19.1	0
0500	50	3	12	14	263	176	720	2.3	288	24.9	18.8	0
0600	43	3	12	14	245	151	800	2.6	289	25.0	18.7	0
0700	34	5	20	23	259	156	280	2.1	292	25.1	18.8	0
0800	16	15	42	55	255	176	2848	1.6	286	25.0	19.1	0.1
0900	10	24	51	72				2.4	273	25.0	19.6	0.2
1000	53	13	19	30				3.0	284	27.0	20.6	0.6
1100	63	17	14	30	230	165	350	3.6	294	29.0	21.0	0.9
1200	66	6	10	15	217	136	500	3.5	309	30.3	21.1	1.1
1300	74	6	10	15	210	141	220	3.6	302	31.3	20.0	1.3
1400	85	5	9	13	214	136	610	3.6	297	31.9	19.4	1.3
1500	87	5	10	14	220	141	730	3.5	300	33.0	28.7	1.2
1600	90	5	11	15	*	156	809	3.4	300	33.4	28.1	1.2
1700	97	5	13	17	233	165	1069	3.3	289	33.5	18.6	1.0
1800	96	5	16	20	226	151	440	3.2	291	33.3	19.0	0.7
1900	88	5	16	20	238	146	220	3.6	285	33.1	18.7	0.4
2000	83	4	18	20	226	151	*	2.7	274	32.5	18.5	0.2
2100	65	4	30	32	233	151	*	2.3	265	31.2	19.0	0
2200	43	3	28	30	315	151	250	1.6	236	29.6	19.9	0
2300	27	4	30	32	297	146	350	2.1	242	28.8	20.5	0
2400	20	4	30	33	256	131	*	2.1	273	28.2	20.8	0

Table B4. Surface Data Collected At Dekalb-Peachtree Airport on 7/15/81.

	GAS DATA							MET. DATA				
Time hr	O_3 ppb	NO ppb	NO_2 ppb	NO_x ppb	$CFCl_3$ ppt	CCl_4 ppt	CH_3CCl_3 ppt	WS m/s	WD deg	TMP °C	DP °C	RAD Ly
0100	19	4	29	31	272	131	*	2.3	277	27.6	20.8	0
0200	17	4	30	32	*	136	*	1.8	281	26.9	20.6	0
0300	25	3	20	22	261	151	*	1.1	263	26.5	20.4	0
0400	29	3	16	18	273	136	2618	0.7	304	26.3	20.3	0
0500	30	3	12	15	331	146	*	0.9	301	25.9	20.1	0
0600	26	3	14	16	275	151	1019	1.7	293	25.5	20.2	0
0700	24	5	17	21	229	156	410	2.5	295	25.4	20.1	0
0800	14	15	31	44				1.9	293	25.5	20.3	0.1
0900	19	16	33	47	236	195	760	2.3	296	26.4	19.9	0.3
1000	35	11	27	36	236	180	480	2.3	298	27.8	21.4	0.5
1100	64	8	15	20	243	161	1319	2.9	298	29.8	22.0	0.9
1200	72	5	11	15	213	156	410	2.9	326	31.0	21.9	1.1
1300	73	5	9	14	240	146	530	2.9	306	31.8	21.1	1.1
1400	76	4	7	12	207	156	410	3.1	291	32.9	20.1	1.2
1500	83	4	7	10	229	156	600	2.9	287	35.6	19.1	1.3
1600	91	4	11	14	223	141	690	3.3	258	33.2	19.2	0.6
1700	71	7	26	31	232	156	1689	3.9	281	31.3	20.4	0.4
1800	68	6	29	33	229	156	2059	2.4	303	31.1	20.8	0.4
1900	57	6	31	35	287	136	*	2.5	294	30.4	20.0	0.1
2000	49	4	22	25	230	146	550	2.3	306	28.9	19.7	0
2100	41	4	29	31	247	161	969	1.3	296	28.3	20.2	0
2200	33	5	32	35	247	146	1519	1.5	316	27.5	20.4	0
2300	38	4	22	24	238	151	1549	1.2	310	26.7	20.2	0
2400	--	--	--	--	309	151	1179	--	--	--	--	--

Table B5. Surface Data Collected At Dekalb-Peachtree Airport on 7/16/81.

	GAS DATA							MET. DATA				
Time	O_3	NO	NO_2	NO_x	$CFCl_3$	CCl_4	CH_3CCl_3	WS	WD	TMP	DP	RAD
hr	ppb	ppb	ppb	ppb	ppt	ppt	ppt	m/s	deg	°C	°C	Ly
0100	24	4	27	29	302	151	*	0.5	274	25.6	20.3	0
0200	19	3	24	26	322	151	1829	0.4	278	24.9	20.4	0
0300	13	3	27	29	417	151	1499	0.4	256	24.2	20.4	0
0400	10	5	31	34	441	151	2948	0.8	280	24.2	20.4	0
0500	3	7	36	42	433	156	*	0.8	288	23.7	20.2	0
0600	1	11	41	49	408	151	*	0.8	274	23.4	20.0	0
0700	0	19	39	55	395	161	1279	0.8	269	23.1	19.9	0
0800	6	30	38	66				2.1	302	23.6	20.0	0.1
0900	19	19	39	56	365	175	*	2.2	291	26.0	21.0	0.4
1000	50	10	17	26	223	165	207	2.7	248	28.1	21.8	0.6
1100	60	6	9	15	219	156	724	3.9	292	29.9	22.0	0.9
1200	71	5	11	16	244	146	*	3.4	349	30.9	21.6	1.0
1300	78	5	11	15	223	151	1138	3.7	288	31.4	20.9	1.0
1400	83	5	10	14	315	156	564	4.1	279	32.4	20.2	1.2
1500	98	4	11	15	263	151	423	4.0	268	33.2	19.5	1.3
1600	96	4	10	13	231	142	*	3.4	268	33.7	19.5	1.1
1700	72	5	9	13	195	146	216	3.8	256	33.0	19.1	1.0
1800	67	8	9	15	227	137	3847	4.0	270	34.1	19.2	0.8
1900	65	6	8	13	231	142	837	4.1	265	33.5	19.4	0.5
2000	69	5	9	13	261	146	*	3.3	260	32.7	19.8	0.2
2100	55	5	11	15	169	151	188	2.5	244	31.2	19.8	0
2200	42	5	16	20	273	146	790	2.7	268	29.9	20.5	0
2300	43	5	12	16	216	151	348	2.3	307	29.0	19.5	0
2400	--	--	--	--	259	151	376	--	--	--	--	--

Table B6. Surface Data Collected At Dekalb-Peachtree Airport on 7/17/81.

	GAS DATA							MET. DATA				
Time hr	O_3 ppb	NO ppb	NO_2 ppb	NO_x ppb	$CFCl_3$ ppt	CCl_4 ppt	CH_3CCl_3 ppt	WS m/s	WD deg	TMP °C	DP °C	RAD Ly
0100	31	5	19	23	306	142	1731	1.2	278	27.0	18.8	0
0200	22	4	20	21	298	151	875	0.4	222	25.5	19.2	0
0300	17	4	23	21	365	142	*	0.5	259	25.1	19.1	0
0400	13	6	28	29	*	109	*	1.4	298	24.9	18.9	0
0500	27	5	13	14	245	146	320	2.3	300	24.4	18.7	0
0600	26	6	12	14	238	160	470	2.6	311	23.8	18.7	0
0700	22	6	17	15	230	156	1326	2.4	294	23.5	18.7	0
0800	--	--	--	--				--	--	--	--	--
0900	--	--	--	--	188	160	172	--	--	--	--	--
1000	--	--	--	--	194	165	162	--	--	--	--	--
1100	--	--	6	--	194	160	162	3.3	283	28.5	20.0	0.9
1200	71	5	9	13	195	160	172	2.9	285	29.5	20.3	1.0
1300	74	7	7	13	195	169	181	2.4	291	30.6	19.9	1.2
1400	78	5	6	12	194	169	162	2.2	290	31.2	19.7	0.9
1500	70	5	7	12	194	160	181	2.7	293	31.9	19.3	0.9
1600	75	5	6	10	195	173	181	2.6	271	32.5	18.9	0.9
1700	93	5	9	14	197	165	172	2.9	256	32.9	19.2	0.8
1800	82	5	15	17	194	165	191	2.2	297	32.6	19.2	0.5
1900	78	5	16	18	194	169	191	1.9	312	32.4	19.3	0.3
2000	74	5	17	19	194	142	220	2.9	295	31.4	19.2	0
2100	62	5	11	13	194	178	191	4.8	312	26.8	18.2	0
2200	49	5	12	12	194	173	200	2.5	34	24.1	19.2	0
2300	37	4	19	15	195	169	191	1.5	87	23.9	19.8	0
2400	20	5	30	20	197	169	200	1.4	288	23.6	20.1	0

Table B7. Surface Data Collected At Dekalb-Peachtree Airport on 7/18/81.

	GAS DATA							MET. DATA				
Time hr	O_3 ppb	NO ppb	NO_2 ppb	NO_x ppb	$CFCl_3$ ppt	CCl_4 ppt	CH_3CCl_3 ppt	WS m/s	WD deg	TMP °C	DP °C	RAD Ly
0100	11	5	35	39	197	169	210	0.8	307	23.4	20.1	0
0200	15	6	27	33	197	178	210	1.0	355	23.1	19.8	0
0300	16	4	10	23	198	182	191	1.0	335	22.8	19.8	0
0400	11	4	18	22	193	178	200	0.8	321	22.3	19.6	0
0500	10	4	15	19	198	191	220	1.3	314	22.0	19.4	0
0600	13	5	13	18	201	196	229	1.4	315	21.8	19.2	0
0700	15	4	10	14	199	182	229	1.3	330	21.9	19.1	0
0800	11	9	15	24	201	187	258	1.3	1	22.2	19.3	0.1
0900	18	9	16	25	198	169	286	1.5	63	23.4	19.9	0.3
1000	29	7	11	18				2.4	81	24.8	20.9	0.5
1100	44	--	1	--	214	163	234	2.6	93	24.5	20.9	0.3
1200	--	--	--	--	203	149	261	--	--	--	--	--
1300	62	--	--	--	200	149	216	2.3	96	26.5	21.1	0.5
1400	64	--	--	--	193	149	333	2.6	72	27.3	21.7	0.9
1500	70	--	--	--	200	153	432	2.6	69	28.5	21.9	0.9
1600	65	--	--	--	203	149	297	3.4	69	28.5	21.9	0.9
1700	69	--	--	--	204	144	712	3.2	67	28.8	21.6	1.0
1800	73	--	--	--	199	153	676	2.7	67	29.4	21.2	0.7
1900	70	--	--	--	208	135	559	2.8	71	29.4	21.2	0.4
2000	66	--	--	--	204	125	225	2.8	74	28.6	21.0	0.2
2100	55	--	--	--	205	158	468	2.4	74	27.4	20.7	0
2200	41	--	--	--	218	149	459	1.4	70	26.6	20.5	0
2300	27	--	--	--	210	153	568	1.5	82	25.9	20.5	0
2400	29	--	--	--	206	153	279	2.2	84	25.2	20.4	0

Table B8. Surface Data Collected At Dekalb-Peachtree Airport on 7/19/81.

			GAS DATA						MET. DATA			
Time hr	O_3 ppb	NO ppb	NO_2 ppb	NO_x ppb	$CFCl_3$ ppt	CCl_4 ppt	CH_3CCl_3 ppt	WS m/s	WD deg	TMP °C	DP °C	RAD Ly
0100	27	--	--	--	209	149	261	2.0	94	24.8	20.6	0
0200	27	--	--	--	205	139	261	1.8	84	24.5	20.5	0
0300	26	--	--	--	--	--	--	1.3	65	24.1	20.3	0
0400	25	--	--	--	--	--	--	1.0	74	23.8	20.2	0
0500	17	--	--	--	--	--	--	0.7	70	23.2	20.0	0
0600	--	--	--	--	--	--	--	--	--	--	--	--
0700	--	--	--	--	--	--	--	--	--	--	--	--
0800	--	--	--	--	--	--	--	--	--	--	--	--
0900	--	--	--	--	--	--	--	--	--	--	--	--
1000	--	--	--	--	--	--	--	--	--	--	--	--
1100	--	--	--	--	--	--	--	--	--	--	--	--
1200	56	--	--	--	202	152	216	1.7	96	28.4	21.4	1.0
1300	64	--	--	--	202	198	298	1.9	146	30.0	21.4	1.1
1400	69	--	--	--	211	157	226	1.6	132	29.9	20.9	0.5
1500	77	--	--	--	206	157	207	1.8	103	31.1	20.9	1.0
1600	84	--	--	--	211	147	376	1.9	197	32.1	20.5	1.1
1700	88	--	--	--	211	147	273	1.9	335	32.6	19.3	1.0
1800	86	--	--	--	213	147	292	1.9	270	33.0	18.7	0.8
1900	83	--	--	--	209	147	310	1.5	269	33.0	18.1	0.5
2000	79	--	--	--	250	147	320	1.9	72	31.8	19.1	0.1
2100	56	--	--	--	236	157	282	2.1	84	30.0	20.7	0
2200	38	--	--	--	222	157	442	1.6	116	28.5	20.6	0
2300	29	--	--	--	218	162	611	1.3	122	28.1	20.7	0
2400	26	--	--	--	209	147	329	1.3	116	27.3	20.2	0

Table B9. Surface Data Collected At Dekalb-Peachtree Airport on 7/20/81.

			GAS DATA						MET. DATA			
Time hr	O_3 ppb	NO ppb	NO_2 ppb	NO_x ppb	$CFCl_3$ ppt	CCl_4 ppt	CH_3CCl_3 ppt	WS m/s	WD deg	TMP °C	DP °C	RAD Ly
0100	29	--	--	--	209	152	329	2.0	130	26.7	19.7	0
0200	23	--	--	--	228	147	339	1.2	197	26.2	20.0	0
0300	15	--	--	--	407	147	1138	0.4	270	25.8	20.1	0
0400	9	--	--	--	263	147	480	0.4	112	25.0	20.2	0
0500	5	--	--	--	257	157	433	0.4	175	24.5	20.2	0
0600	2	--	--	--	273	152	630	0.6	134	23.9	20.1	0
0700	0	--	--	--	258	147	752	0.8	157	23.9	20.2	0
0800	1	--	--	--				1.8	261	24.2	20.5	0.1
0900	5	--	--	--				2.5	262	25.3	20.9	0.3
1000	13	--	--	--	221	151	770	2.4	269	26.9	21.0	0.6
1100	54	--	--	--	330	151	*	2.9	289	28.9	21.2	0.8
1200	70	--	--	--	213	156	580	3.4	286	30.5	21.2	0.9
1300	77	--	--	--	216	156	460	3.0	277	30.8	21.2	0.9
1400	71	--	--	--	208	151	710	2.9	285	31.6	21.2	0.7
1500	87	--	--	-	230	156	500	4.0	288	32.4	20.5	1.1
1600	88	--	--	--	219	151	1529	3.7	279	33.4	19.9	1.1
1700	72	--	--	--	200	146	770	3.9	280	34.1	19.3	1.0
1800	70	--	--	--	194	141	400	3.7	274	33.5	19.1	0.5
1900	66	--	--	--	195	146	630	3.0	267	33.0	19.5	0.3
2000	62	--	--	--	198	151	380	2.9	246	32.5	19.7	0.2
2100	52	--	--	--	208	141	240	2.1	245	31.3	19.3	0
2200	36	--	--	--	--	--	--	1.1	231	30.1	19.3	0
2300	30	--	--	--	--	--	--	2.0	228	29.4	19.5	0
2400	32	--	--	--	--	--	--	2.5	213	28.1	20.9	0

Table B10. Surface Data Collected At Dekalb-Peachtree Airport on 7/21/81.

	GAS DATA							MET. DATA				
Time hr	O_3 ppb	NO ppb	NO_2 ppb	NO_x ppb	$CFCl_3$ ppt	CCl_4 ppt	CH_3CCl_3 ppt	WS m/s	WD deg	TMP °C	DP °C	RAD Ly
0100	34	--	--	--	--	--	--	2.9	221	26.7	21.1	0
0200	33	--	--	--	--	--	--	2.9	236	25.8	21.1	0
0300	31	--	--	--	--	--	--	3.1	256	25.4	21.1	0
0400	41	--	--	--	--	--	--	3.2	292	25.9	17.8	0
0500	49	--	--	--	--	—	--	3.0	286	25.0	14.4	0
0600	46	--	--	--	--	--	--	2.8	264	23.5	14.1	0
0700	41	--	--	--	--	—	--	1.9	227	22.2	13.8	0
0800	17	--	--	--	--	--	--	2.2	248	22.4	13.9	0.1
0900	20	--	--	--	--	--	--	3.3	261	23.9	14.5	0.4
1000	34	--	--	—	227	160	1179	2.9	297	25.7	14.8	0.7
1100	49	--	--	--	233	236	600	3.3	287	27.8	14.4	1.0
1200	63	--	--	--	306	231	440	3.5	301	29.7	13.6	1.2
1300	69	--	--	--	241	216	250	3.9	286	30.3	13.7	1.3
1400	76	--	--	--	196	192	360	3.9	274	31.1	14.4	1.4
1500	81	--	--	--	211	167	540	4.5	277	31.6	15.9	1.3
1600	77	--	--	--	228	201	1009	5.3	283	31.9	15.9	1.3
1700	73	--	--	--	221	138	560	4.6	283	32.6	15.7	1.1
1800	70	--	--	--	207	142	220	4.1	300	32.7	15.4	0.7
1900	79	--	--	--	212	167	290	3.9	294	32.4	14.9	0.5
2000	83	--	--	--	247	147	1199	3.8	278	31.6	14.4	0.2
2100	62	--	--	—	241	152	919	2.7	285	30.1	13.3	0
2200	33	--	--	--	321	142	1539	1.5	291	28.2	13.1	0
2300	17	--	--	--	273	157	1659	0.9	317	26.8	13.6	0
2400	14	--	--	--	259	162	440	1.0	318	25.7	13.6	0

Table B11. Surface Data Collected At Dekalb-Peachtree Airport on 7/22/81.

	GAS DATA							MET. DATA				
Time hr	O_3 ppb	NO ppb	NO_2 ppb	NO_x ppb	$CFCl_3$ ppt	CCl_4 ppt	CH_3CCl_3 ppt	WS m/s	WD deg	TMP °C	DP °C	RAD Ly
0100	17	--	--	--	278	167	1379	0.7	315	25.1	13.8	0
0200	12	--	--	--	318	172	*	0.8	315	23.9	14.4	0
0300	25	--	--	--	309	201	1649	1.2	312	23.5	14.5	0
0400	34	--	--	--	254	187	480	1.2	313	23.2	14.8	0
0500	35	--	--	--	270	187	470	0.6	321	22.7	15.0	0
0600	35	--	--	--	279	187	1389	0.9	311	22.2	15.2	0
0700	24	--	--	--	*	177	*	0.4	307	21.6	15.4	0
0800	17	--	--	--				0.9	299	22.1	15.9	0.1
0900	25	--	--	--	209	158	227	1.1	297	23.5	16.8	0.4
1000	41	--	--	--	220	161	475	1.9	312	25.3	17.4	0.7
1100	59	--	--	--	218	166	691	2.6	323	27.2	17.7	1.0
1200	63	--	--	--	224	166	217	3.3	308	28.9	17.1	1.2
1300	63	--	--	--	204	166	309	3.1	310	29.9	16.2	1.3
1400	67	--	--	--	203	161	475	3.0	326	30.7	14.8	1.4
1500	67	--	--	—	198	161	320	2.5	344	31.5	13.5	1.3
1600	65	--	--	--	203	161	330	3.1	--	--	--	--
1700	65	--	--	--	207	166	237	3.7	303	32.4	13.2	1.0
1800	67	--	--	--	212	156	289	4.1	--	--	--	--
1900	75	--	--	--	217	161	732	4.0	285	31.7	13.4	0.5
2000	69	--	--	--	212	151	289	3.3	306	30.7	13.7	0.2
2100	57	--	--	--	224	151	268	2.3	305	29.3	13.4	0
2200	46	--	--	--	220	151	320	1.6	307	27.6	13.4	0
2300	39	--	--	--	245	146	1104	1.2	314	26.4	13.8	0
2400	38	--	--	--	227	141	413	1.0	310	25.3	13.9	0

Table B12. Surface Data Collected At Dekalb-Peachtree Airport on 7/23/81.

	GAS DATA							MET. DATA				
Time hr	O_3 ppb	NO ppb	NO_2 ppb	NO_x ppb	$CFCl_3$ ppt	CCl_4 ppt	CH_3CCl_3 ppt	WS m/s	WD deg	TMP °C	DP °C	RAD Ly
0100	51	--	--	--	229	151	1156	1.6	319	24.7	14.3	0
0200	56	--	--	--	235	151	990	1.5	311	23.6	14.5	0
0300	56	--	--	--	248	151	1475	1.6	317	22.9	14.5	0
0400	52	--	--	--	234	151	928	1.7	335	22.7	14.6	0
0500	48	--	--	--	258	151	794	1.1	24	22.2	14.6	0
0600	40	--	--	--	287	171	1733	1.3	349	21.5	14.4	0
0700	22	--	--	—	265	156	691	0.9	343	21.0	14.5	0
0800	19	--	--	--				2.1	53	22.2	14.9	0.1
0900	30	--	--	--	229	166	362	2.9	63	23.7	15.6	0.4
1000	46	--	--	--	249	161	1141	3.7	82	25.5	16.1	0.7
1100	66	--	--	--	242	156	608	3.7	83	26.8	16.7	0.9
1200	81	--	--	--	238	145	981	3.0	79	28.2	17.4	1.2
1300	92	--	--	--	227	156	448	2.4	85	29.5	17.6	1.3
1400	99	--	--	--	222	151	554	2.0	65	30.5	17.4	1.2
1500	--	--	--	--	235	156	544	--	--	--	--	--
1600	--	--	--	—	262	156	640	--	--	--	--	--
1700	96	--	--	--	220	161	298	2.5	5	32.8	15.7	1.1
1800	93	--	--	—	218	156	490	2.0	69	32.7	15.2	0.8
1900	88	--	--	--	213	156	1269	1.9	19	32.6	14.9	0.5
2000	84	--	--	--	212	156	352	1.8	25	32.0	15.0	0.2
2100	58	--	--	--	225	151	501	1.4	83	30.5	14.7	0
2200	26	--	--	--	343	161	2025	1.2	35	29.5	14.9	0
2300	2	--	--	--	344	161	2195	0.6	114	27.7	15.7	0
2400	1	--	--	--	382	156	*	1.3	339	26.7	15.8	0

Table B13. Surface Data Collected At Dekalb-Peachtree Airport on 7/24/81.

	GAS DATA							MET. DATA				
Time hr	O_3 ppb	NO ppb	NO_2 ppb	NO_x ppb	$CFCl_3$ ppt	CCl_4 ppt	CH_3CCl_3 ppt	WS m/s	WD deg	TMP °C	DP °C	RAD Ly
0100	1	--	--	--	486	151	*	1.2	341	26.2	16.2	0
0200	22	--	--	--	271	156	1460	1.6	50	26.1	16.7	0
0300	40	--	--	--	230	156	672	1.9	88	25.3	17.5	0
0400	35	--	--	--	257	156	1908	1.4	85	24.3	17.8	0
0500	32	--	--	--	245	151	778	1.5	73	23.7	18.2	0
0600	30	--	--	--	244	151	512	2.0	76	23.1	18.5	0
0700	22	--	--	--	234	151	938	1.9	81	22.5	18.6	0
0800	13	--	--	--	245	145	704	1.8	77	22.8	18.9	0.1
0900	17	--	--	--	249	156	1759	2.8	81	23.8	19.3	0.3
1000	40	--	--	--	208	145	309	2.4	91	25.2	20.0	0.6
1100	57	--	--	--	*	151	320	1.9	83	27.0	20.6	0.9
1200	76	--	--	--	384	145	405	1.0	105	29.2	20.7	1.1
1300	99	--	--	--	325	145	725	1.5	50	30.4	20.2	1.1
1400	126	--	--	--	*	151	384	1.9	155	32.2	19.0	1.3
1500	134	--	--	--	*	151	554	2.0	356	33.1	17.9	1.2
1600	159	--	--	--				1.9	256	33.6	17.3	1.0
1700	172	--	--	--	191	163	186	1.5	291	33.6	17.0	0.7
1800	163	--	--	--	219	174	836	1.8	261	33.8	16.5	0.4
1900	146	--	--	--	269	153	763	1.5	259	34.1	16.3	0.4
2000	119	--	--	--	232	153	475	1.2	229	33.6	16.3	0.2
2100	92	--	--	--	360	179	*	1.0	3	32.3	17.4	0
2200	30	--	--	--	412	148	*	1.1	295	30.2	18.8	0
2300	52	--	--	--	197	158	237	4.6	308	27.6	17.9	0
2400	58	--	--	--	196	163	217	3.0	309	25.4	17.3	0

Table B14. Surface Data Collected At Dekalb-Peachtree Airport on 7/25/81.

	GAS DATA							MET. DATA				
Time hr	O_3 ppb	NO ppb	NO_2 ppb	NO_x ppb	$CFCl_3$ ppt	CCl_4 ppt	CH_3CCl_3 ppt	WS m/s	WD deg	TMP °C	DP °C	RAD Ly
0100	54	--	--	--	217	163	619	1.4	38	24.5	17.3	0
0200	49	--	--	--	206	148	289	1.0	82	24.2	17.4	0
0300	34	--	--	--	219	158	392	1.4	124	23.8	17.5	0
0400	24	--	--	--	235	158	1217	1.4	322	23.0	17.7	0
0500	38	--	--	--	222	158	433	1.4	38	23.0	17.4	0
0600	39	--	--	--	236	153	980	0.6	64	22.9	17.4	0
0700	34	--	--	--	292	158	1516	1.3	310	22.4	17.5	0
0800	26	--	--	--	241	158	557	1.1	315	22.3	17.7	0
0900	34	--	--	--				1.5	320	23.0	18.2	0.2
1000	46	--	--	--	201	144	231	2.0	311	24.5	18.7	0.6
1100	56	--	--	--	221	135	249	2.0	314	26.0	19.3	0.8
1200	74	--	--	--	193	135	213	2.0	295	28.4	19.1	1.0
1300	--	--	--	--	242	144	773	--	--	--	--	--
1400	--	--	--	--	196	135	657	--	--	--	--	--
1500	58	--	--	--	199	135	551	3.5	286	29.6	15.5	0.6
1600	81	--	--	--	190	135	222	2.3	304	29.7	16.7	0.6
1700	103	--	--	--	209	139	258	2.0	275	30.7	17.7	0.9
1800	109	--	--	--	185	135	249	1.7	269	31.7	18.4	0.8
1900	86	--	--	--	180	153	160	2.2	298	32.2	17.5	0.5
2000	73	--	--	--	182	139	169	2.0	299	31.7	17.2	0.2
2100	61	--	--	--	220	149	320	1.4	290	30.5	17.8	0
2200	16	--	--	--	230	144	*	0.4	252	28.3	18.6	0
2300	8	--	--	--	329	139	*	0.4	264	27.3	18.8	0
2400	4	--	--	--	337	139	*	0.9	315	27.0	19.1	0

Table B15. Surface Data Collected At Dekalb-Peachtree Airport on 7/26/81.

Time	GAS DATA							MET. DATA				
Time hr	O_3 ppb	NO ppb	NO_2 ppb	NO_x ppb	$CFCl_3$ ppt	CCl_4 ppt	CH_3CCl_3 ppt	WS m/s	WD deg	TMP °C	DP °C	RAD Ly
0100	2	--	--	--	*	144	*	0.7	332	26.2	19.2	0
0200	4	--	--	--	265	149	977	0.6	340	25.6	19.2	0
0300	0	--	--	--	294	153	1404	0.5	115	24.4	19.2	0
0400	0	--	--	--	311	153	1217	0.5	238	24.0	19.1	0
0500	0	--	--	--	*	153	*	0.6	282	24.0	19.3	0
0600	0	--	--	--	430	149	*	0.5	255	23.3	19.4	0
0700	0	--	--	--	383	163	2514	1.3	351	23.1	19.2	0
0800	8	--	--	--	284	167	657	0.7	14	23.2	19.2	0.1
0900	36	--	--	--	241	163	1430	0.6	18	24.3	19.8	0.3
1000	55	--	--	--	218	158	897	1.1	26	26.2	20.2	0.6
1100	80	--	--	--	209	153	746	1.2	154	28.6	20.5	0.8
1200	88	--	--	--	209	144	533	2.0	209	30.6	20.4	1.1
1300	102	--	--	--	202	153	275	2.2	233	31.8	20.2	1.1
1400	108	--	--	--	222	144	293	2.6	267	32.4	19.2	1.2
1500	90	--	--	--	207	139	444	2.2	290	32.7	18.9	0.8
1600	78	--	--	--	193	149	258	2.6	322	34.0	18.6	0.9
1700	83	--	--	--				3.2	300	33.4	18.1	0.4
1800	93	--	--	--				4.0	187	29.3	19.2	0.3
1900	63	--	--	--								
2000												
2100												
2200												
2300												
2400												

Table B16. Surface Data Collected At Dekalb-Peachtree Airport on 7/27/81.

	GAS DATA							MET. DATA				
Time hr	O_3 ppb	NO ppb	NO_2 ppb	NO_x ppb	$CFCl_3$ ppt	CCl_4 ppt	CH_3CCl_3 ppt	WS m/s	WD deg	TMP °C	DP °C	RAD Ly
0100	--											
0200	--											
0300	--											
0400	--											
0500	--											
0600	--											
0700	--											
0800	--											
0900	1	--	--	--				1.4	329	23.8	26.1	0.3
1000	9	--	--	--				2.2	276	25.5	24.3	0.5
1100	26	--	--	--				2.0	282	26.9	24.1	0.7
1200	54	--	--	--	350	181	2600	1.9	261	28.7	23.9	0.8
1300	66	--	--	--	308	166	980	2.5	269	30.2	23.2	1.0
1400	73	--	--	--	266	171	794	2.7	280	31.2	22.5	1.0
1500	99	--	--	--	226	156	371	2.5	259	31.6	22.0	0.8
1600	105	--	--	--	221	161	423	2.2	221	32.1	21.5	0.9
1700	111	--	--	--	250	161	392	2.7	228	32.5	20.9	0.8
1800	104	--	--	--	220	156	1393	2.7	261	32.5	20.7	0.6
1900	97	--	--	--	243	161	423	2.2	230	32.2	20.6	0.4
2000	54	--	--	--	234	161	1166	2.7	228	30.4	20.7	0.2
2100	34	--	--	--	223	156	557	1.7	226	29.3	20.6	0
2200	13	--	--	--	337	156	1475	1.3	241	28.1	20.2	0
2300	1	--	--	--	308	156	1486	1.0	247	26.7	20.0	0
2400	0	--	--	--	248	146	*	1.0	258	26.0	20.0	0

Table B17. Surface Data Collected At Dekalb-Peachtree Airport on 7/28/81.

	GAS DATA							MET. DATA				
Time hr	O_3 ppb	NO ppb	NO_2 ppb	NO_x ppb	$CFCl_3$ ppt	CCl_4 ppt	CH_3CCl_3 ppt	WS m/s	WD deg	TMP °C	DP °C	RAD Ly
0100	0	--	--	--	308	156	*	1.0	263	25.7	20.1	0
0200	0	--	--	--	305	151	1393	0.4	252	25.0	20.0	0
0300	0	--	--	--	310	151	1981	0.4	257	24.9	19.9	0
0400	0	--	--	--	440	146	2300	0.6	126	24.2	19.8	0
0500	0	--	--	--	419	161	1682	0.5	126	23.9	19.6	0
0600	0	--	--	--	429	241	1516	0.4	123	23.7	19.4	0
0700	0	--	--	--	388	171	1465	0.5	138	23.2	19.0	0
0800	1	--	--	--	365	171	1135	0.4	244	23.9	18.8	0
0900	5	--	--	--	377	161	1506	1.9	238	25.7	19.6	0.1
1000	17	--	--	--	266	156	2342	3.4	268	27.5	19.9	0.3
1100	46	--	--	--	250	146	1362	3.9	268	29.6	19.9	0.6
1200	50	--	--	--	221	151	2239	3.7	281	30.9	20.3	0.9
1300	51	--	--	--	211	151	1186	3.5	260	31.9	19.7	1.0
1400	48	--	--	--	197	151	1114	4.0	276	32.4	19.3	1.1
1500	47	--	--	--	197	151	229	4.3	253	32.9	18.6	1.2
1600	51	--	--	--	222	151	289	4.3	242	33.4	18.7	1.2
1700	53	--	--	--	197	156	1382	4.1	269	33.8	18.0	1.2
1800	50	--	--	--	200	156	1733	4.2	246	33.6	18.4	1.0
1900	46	--	--	--				3.0	233	32.7	18.8	0.8
2000	47	--	--	--	209	161	392	3.0	228	32.0	18.6	0.4
2100	34	--	--	--	283	156	691	1.5	241	30.3	18.6	0.2
2200	14	--	--	--	323	151	1063	0.9	253	29.4	17.9	0
2300	1	--	--	--	468	151	1320	0.4	240	27.6	18.2	0
2400	0	--	--	--	291	151	2239	0.5	229	26.7	19.0	0

Table B18. Surface Data Collected At Dekalb-Peachtree Airport on 7/29/81.

	GAS DATA							MET. DATA				
Time hr	O_3 ppb	NO ppb	NO_2 ppb	NO_x ppb	$CFCl_3$ ppt	CCl_4 ppt	CH_3CCl_3 ppt	WS m/s	WD deg	TMP °C	DP °C	RAD Ly
0100	0	--	--	--	308	156	2197	0.4	242	26.1	19.0	0
0200	0	--	--	--	297	151	1712	0.6	208	26.0	18.3	0
0300	1	--	--	--	255	151	1475	1.1	231	25.7	17.8	0
0400	0	--	--	--	228	161	1950	2.1	257	24.9	17.4	0
0500	0	--	--	--	258	151	1104	1.2	249	24.1	17.5	0
0600	3	--	--	--	218	156	2723	1.9	258	23.9	17.2	0
0700	1	--	--	--	254	151	*	1.4	281	23.8	17.1	0
0800	1	--	--	--	*	151	867	0.8	226	23.4	17.4	0.1
0900	6	--	--	--	250	146	*	2.3	263	25.4	18.1	0.3
1000	13	--	--	--	253	156	2651	2.3	285	26.6	18.9	0.4
1100	27	--	--	--	228	156	887	2.2	288	27.3	19.6	0.4
1200	43	--	--	--	225	151	578	2.5	244	28.1	19.9	0.7
1300	56	--	--	--	239	151	712	2.7	246	29.1	20.2	0.7
1400	49	--	--	--	292	156	526	3.2	260	29.9	19.7	1.0
1500	68	--	--	--	195	156	309	3.1	254	30.9	19.8	1.1
1600	55	--	--	--				4.3	276	29.0	19.0	0.4
1700	30	--	--	--	224	166	1149	2.2	308	24.9	18.3	0.1
1800	20	--	--	--	220	151	490	2.8	233	24.7	18.8	0.1
1900	--	--	--	--	211	151	909	--	--	--	--	--
2000	--	--	--	--	207	151	849	--	--	--	--	--
2100	3	--	--	--	201	146	3108	2.0	265	23.3	18.6	0
2200	1	--	--	--	205	151	1519	2.0	250	23.1	18.7	0
2300	4	--	--	--	221	146	2038	2.4	279	22.9	18.6	0
2400	6	--	--	--	215	146	2588	2.0	287	22.8	18.4	0

Table B19. Surface Data Collected At Dekalb-Peachtree Airport on 7/30/81.

			GAS DATA						MET. DATA			
Time hr	O_3 ppb	NO ppb	NO_2 ppb	NO_x ppb	$CFCl_3$ ppt	CCl_4 ppt	CH_3CCl_3 ppt	WS m/s	WD deg	TMP °C	DP °C	RAD Ly
0100	17	--	--	--	218	181	300	2.2	299	22.8	18.2	0
0200	27	--	--	--	204	171	590	2.1	306	22.7	17.8	0
0300	25	--	--	--	211	166	*	1.4	292	22.3	17.5	0
0400	21	--	--	--	251	166	1229	1.2	266	21.8	17.2	0
0500	18	--	--	--	211	161	1409	1.7	280	21.7	17.1	0
0600	20	--	--	--	210	156	770	2.3	286	21.2	16.5	0
0700	14	--	--	--	212	151	710	1.8	289	20.6	16.0	0
0800	7	--	--	--	211	151	1889	1.5	328	20.6	16.1	0
0900	6	--	--	--	237	151	*	1.6	13	21.1	16.5	0.2
1000	8	--	--	--	249	156	1099	1.9	47	22.4	17.2	0.1
1100	22	--	--	--	223	151	350	3.8	67	21.0	16.2	0.1
1200	32	--	--	--	216	156	590	4.0	78	21.5	15.2	0.4
1300	38	--	—	--	219	161	300	4.4	78	22.1	15.1	0.5
1400	45	--	--	--	225	156	300	5.0	87	23.0	15.6	0.9
1500	44	--	--	--	240	161	510	4.5	79	22.1	15.1	0.5
1600	46	--	--	--	215	161	320	4.6	80	22.2	14.9	0.8
1700	48	--	--	--				4.3	80	22.9	15.0	0.8
1800	53	--	--	--	236	168	329	4.5	90	23.3	15.3	0.7
1900	52	--	--	--	244	158	433	3.7	85	23.1	14.9	0.3
2000	51	--	--	--	235	153	414	4.0	84	22.3	14.3	0.1
2100	44	--	--	--	227	153	442	3.6	74	21.3	13.2	0
2200	38	--	--	--	225	153	442	4.3	78	20.1	12.7	0
2300	30	--	--	--	253	158	564	3.4	76	19.4	12.5	0
2400	29	--	--	--	260	158	499	3.4	83	18.9	12.0	0

Table B20. Surface Data Collected At Dekalb-Peachtree Airport on 7/31/81.

	GAS DATA							MET. DATA				
Time hr	O_3 ppb	NO ppb	NO_2 ppb	NO_x ppb	$CFCl_3$ ppt	CCl_4 ppt	CH_3CCl_3 ppt	WS m/s	WD deg	TMP °C	DP °C	RAD Ly
0100	27	--	--	--	250	158	489	3.4	82	18.5	11.8	0
0200	31	--	--	--	273	158	433	3.4	78	18.5	11.6	0
0300	33	--	--	--	255	158	433	3.5	86	18.4	11.5	0
0400	35	--	--	--	241	158	404	3.6	76	18.2	11.9	0
0500	37	--	--	--	237	163	310	3.4	74	18.0	12.2	0
0600	36	--	--	--	231	158	461	3.1	87	18.2	12.1	0
0700	35	--	--	--	236	158	357	2.1	70	18.0	12.5	0
0800	18	--	--	--	253	153	1044	0.9	35	17.3	16.2	0
0900	6	--	--	--				2.0	49	17.5	16.2	0
1000	18	--	--	—	312	157	596	2.5	57	17.7	16.3	0.1
1100	21	--	--	--	254	157	334	2.4	67	17.9	16.4	0.1
1200	23	--	--	--	243	147	334	2.6	67	17.9	16.5	0.1
1300	21	--	--	--	251	142	632	2.7	74	18.1	16.7	0.2
1400	24	--	--	--	248	147	524	3.2	70	18.3	16.8	0.1
1500	26	--	--	--	252	142	1129	3.5	79	18.4	16.8	0.2
1600	28	--	--	--	244	142	334	3.7	65	18.0	16.4	0.1
1700	28	--	--	--	235	147	632	3.1	65	17.5	15.8	0.1
1800	25	--	--	--	256	147	1102	2.4	58	17.9	16.2	0.1
1900	23	--	--	--	256	147	560	2.2	58	18.0	16.2	0
2000	16	--	--	--	252	157	705	1.9	47	18.2	16.4	0
2100	17	--	--	--	253	142	569	1.4	57	18.4	16.4	0
2200	6	--	--	--	253	142	813	1.5	60	18.7	14.8	0
2300	4	--	--	-	267	142	1427	1.7	79	19.0	13.8	0
2400	9	--	--	-	320	133	1599	2.1	76	18.9	13.4	0

Table B21. Surface Data Collected At Dekalb-Peachtree Airport on 8/1/81.

	GAS DATA							MET. DATA				
Time hr	O_3 ppb	NO ppb	NO_2 ppb	NO_x ppb	$CFCl_3$ ppt	CCl_4 ppt	CH_3CCl_3 ppt	WS m/s	WD deg	TMP °C	DP °C	RAD Ly
0100	22	--	--	--	305	147	759	2.7	79	18.8	13.2	0
0200	29	--	--	--	287	157	397	3.0	81	18.2	13.3	0
0300	27	--	--	--	285	152	578	3.0	75	18.2	13.5	0
0400	29	--	--	--	271	142	352	2.7	72	18.1	13.5	0
0500	31	--	--	--	254	142	361	3.1	75	18.0	13.3	0
0600	30	--	--	--	253	142	388	2.9	72	17.7	13.2	0
0700	30	--	--	--	244	142	361	2.9	72	17.7	13.1	0
0800	27	--	--	--	244	147	280	2.9	73	18.0	13.3	0
0900	26	--	--	--	252	147	334	2.9	73	18.2	13.4	0
1000	23	--	--	--	260	147	343	2.6	70	18.4	13.7	0
1100	23	--	--	--	256	152	298	2.8	71	18.8	14.1	0.1
1200	20	--	--	--	253	152	325	2.5	66	18.9	14.2	0.1
1300	18	--	--	--	242	152	397	2.1	61	19.4	15.0	0.2
1400	23	--	--	--	231	142	289	2.4	68	19.7	15.5	0.2
1500	21	--	--	--	238	147	452	2.3	71	19.8	15.8	0.1
1600	21	--	--	--	236	147	533	2.3	66	19.8	16.0	0.1
1700	--	--	--	--	227	147	461	--	--	--	--	--
1800	--	--	--	--	227	142	388	—	--	--	--	--
1900	30	--	--	--	217	142	687	2.6	71	19.7	15.6	0.1
2000	31	--	--	—	213	152	370	2.9	70	19.2	15.1	0
2100	33	--	--	--	209	147	289	2.9	71	18.6	14.2	0
2200	28	--	--	--	213	138	379	2.4	74	18.3	14.0	0
2300	26	--	--	—	218	142	307	2.6	83	18.4	14.0	0
2400	26	--	--	--	230	152	361	1.7	67	18.2	14.1	0

Table B22. Surface Data Collected At Dekalb-Peachtree Airport on 8/2/81.

	GAS DATA							MET. DATA				
Time hr	O_3 ppb	NO ppb	NO_2 ppb	NO_x ppb	$CFCl_3$ ppt	CCl_4 ppt	CH_3CCl_3 ppt	WS m/s	WD deg	TMP °C	DP °C	RAD Ly
0100	25	--	--	--	229	147	461	2.0	65	18.2	14.1	0
0200	30	--	--	—	234	142	298	2.0	75	17.8	13.7	0
0300	31	--	--	--	229	147	280	2.0	85	17.5	13.5	0
0400	28	--	--	--	231	147	280	1.9	85	17.5	13.6	0
0500	28	--	—	--	230	142	379	1.7	82	17.7	13.8	0
0600	27	--	--	--	240	138	370	1.5	69	18.0	14.0	0
0700	25	--	--	--	244	147	407	1.3	67	18.2	14.0	0
0800	23	--	--	--	235	147	316	1.5	77	18.3	14.1	0
0900	21	--	--	--	240	147	361	1.4	62	18.4	14.3	0.1
1000	18	--	--	--	243	142	388	1.9	74	19.1	14.9	0.2
1100	17	--	--	--	242	142	452	2.3	87	20.1	15.6	0.3
1200	17	--	--	--	231	142	370	2.0	87	21.1	16.2	0.4
1300	25	--	--	--	226	147	370	1.6	57	22.1	17.2	0.6
1400	35	--	--	--	212	142	262	1.7	81	23.5	17.8	0.5
1500	37	--	--	--	204	142	235	1.5	89	23.5	17.3	0.2
1600	34	--	--	--	208	157	289	1.6	80	23.9	17.7	0.3
1700	35	--	--	--	213	142	307	2.4	81	24.9	18.1	0.7
1800	39	--	--	--	206	142	235	2.3	74	25.5	18.6	0.8
1900	38	--	--	--	209	142	271	2.5	93	25.7	18.3	0.4
2000	37	--	--	--	206	142	226	1.7	90	25.1	17.8	0.1
2100	19	--	--	--	249	152	325	1.0	85	23.8	17.5	0
2200	2	--	--	--	242	147	334	0.5	106	22.6	17.2	0
2300	0	--	--	--	239	147	1084	1.0	66	22.4	17.0	0
2400	0	--	--	--	244	152	479	1.0	99	21.5	16.5	0

Table B23.Surface Data Collected At Dekalb-Peachtree Airport on 8/3/81.

Time	GAS DATA							MET. DATA				
Time	O_3	NO	NO_2	NO_x	$CFCl_3$	CCl_4	CH_3CCl_3	WS	WD	TMP	DP	RAD
hr	ppb	ppb	ppb	ppb	ppt	ppt	ppt	m/s	deg	°C	°C	Ly
0100	0	--	--	--	278	157	352	1.1	87	21.3	16.6	0
0200	3	--	--	--	226	147	443	0.8	91	21.2	16.6	0
0300	6	--	--	—	233	147	587	0.6	81	20.3	16.4	0
0400	6	--	--	--	253	142	578	1.1	68	20.8	16.3	0
0500	0	--	--	--	281	138	786	0.6	89	20.4	16.1	0
0600	0	--	--	--	263	138	687	0.6	67	20.4	16.2	0
0700	0	--	--	--	256	142	723	1.2	85	20.5	15.9	0
0800	0	--	--	--	235	142	434	1.1	89	20.5	15.8	0
0900	3	--	--	--	247	142	416	1.5	94	20.8	16.5	0.1
1000	11	--	--	--	204	147	253	1.6	141	22.0	17.1	0.2
1100	25	--	--	--				1.2	154	23.6	18.9	0.7
1200	45	--	--	--	193	157	153	1.7	159	26.2	20.0	1.2
1300	54	--	--	—				2.1	214	27.2	19.4	0.7
1400	71	--	--	—				1.9	213	28.2	18.6	0.9
1500												
1600												
1700												
1800												
1900												
2000												
2100												
2200												
2300												
2400												

Appendix C

Upper Level Winds Measured at
Dekalb-Peachtree Airport in Atlanta, GA

Table C1. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/14/81	1100	182	--	--	7/14/81	1400	182	--	--
		526	14	330			526	8	325
		849	17	335			849	9	319
		1173	15	338			1173	9	319
		1496	21	341			1496	10	325
		1820	22	346			1820	8	322
		2143	23	338			2143	9	324
		2467	21	345			2467	3	335
		2790	17	343			2790	7	334
		3114	17	344			3114	7	346
		3423	17	348			3423		
		3718	16	340			3718		
		4015	18	339			4015		
		4312	15	335			4312		
		4609	17	335			4609		
		4907	15	331			4907		
		5204					5204		
		5501					5501		
		5798					5798		
		6095					6095		
		6392					6392		
		6689					6689		
		6986					6986		
		7283					7283		
		7580					7580		
		7877					7877		
		8174					8174		
		8472					8472		
		8769					8769		
		9066					9066		
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C2. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/14/81	1600	182	5	332	7/15/81	0900	182	--	--
		526	9	329			526	9	331
		849	11	317			849	16	341
		1173	10	324			1173	18	348
		1496	8	325			1496	19	337
		1820	10	327			1820	18	330
		2143	7	330			2143	20	12
		2467	10	309			2467	16	318
		2790	5	302			2790	20	20
		3114	9	311			3114	23	296
		3423	9	313			3423	15	330
		3718	12	321			3718	15	328
		4015	5	039			4015	15	328
		4312	11	356			4312	13	327
		4609	8	020			4609	21	325
		4907	9	010			4907	11	332
		5204	12	350			5204	17	325
		5501					5501	16	330
		5798					5798	16	319
		6095					6095		
		6392					6392		
		6689					6689		
		6986					6986		
		7283					7283		
		7580					7580		
		7877					7877		
		8174					8174		
		8472					8472		
		8769					8769		
		9066					9066		
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C3. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/15/81	1100	182	9	327	7/15/81	1400	182	--	--
		526	11	345			526	7	323
		849	12	345			849	11	322
		1173	14	336			1173	11	325
		1496	12	322			1496	12	294
		1820	14	326			1820	12	312
		2143	11	333			2143	--	--
		2467	19	315			2467	12	306
		2790	14	314			2790	5	263
		3114	14	317			3114		
		3423	12	322			3423		
		3718	11	320			3718		
		4015	14	316			4015		
		4312	12	315			4312		
		4609	13	322			4609		
		4907	13	326			4907		
		5204	14	327			5204		
		5501	15	328			5501		
		5798	15	331			5798		
		6095	14	330			6095		
		6392					6392		
		6689					6689		
		6986					6986		
		7283					7283		
		7580					7580		
		7877					7877		
		8174					8174		
		8472					8472		
		8769					8769		
		9066					9066		
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C4. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/15/81	1600	182	11	267	7/16/81	0900	182	5	324
		526	10	275			526	14	312
		849	11	279			849	21	318
		1173	11	271			1173	22	333
		1496	11	280			1496	23	321
		1820	11	281			1820	22	319
		2143	10	276			2143	21	321
		2467	8	272			2467	22	299
		2790	7	295			2790	22	323
		3114	3	294			3114	20	305
		3423	9	289			3423	19	310
		3718	5	290			3718	19	309
		4015	5	284			4015	18	309
		4312	3	292			4312	18	308
		4609	3	284			4609	16	306
		4907	2	296			4907	18	306
		5204	4	324			5204	16	299
		5501	4	3			5501		
		5798	4	10			5798		
		6095	5	345			6095		
		6392	4	343			6392		
		6689	5	335			6689		
		6986	6	326			6986		
		7283	21	212			7283		
		7580	8	330			7580		
		7877	34	4			7877		
		8174	15	324			8174		
		8472	14	321			8472		
		8769					8769		
		9066					9066		
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C5. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/16/81	1100	182	14	309	7/16/81	1408	182	8	285
		526	16	321			526	9	296
		849	13	318			849	13	290
		1173	15	316			1173	12	292
		1496	18	321			1496	13	291
		1820	18	321			1820	14	296
		2143	20	323			2143	13	297
		2467	19	317			2467	9	303
		2790	19	317			2790	11	313
		3114	17	315			3114	12	313
		3423	15	312			3423	12	310
		3718	17	309			3718	14	305
		4015	19	294			4015	12	307
		4312					4312		
		4609					4609		
		4907					4907		
		5204					5204		
		5501					5501		
		5798					5798		
		6095					6095		
		6392					6392		
		6689					6689		
		6986					6986		
		7283					7283		
		7580					7580		
		7877					7877		
		8174					8174		
		8472					8472		
		8769					8769		
		9066					9066		
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C6. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/16/81	1605	182	15	254	7/17/81	0900	182	6	312
		526	8	255			526	9	334
		849	12	277			849	15	324
		1173	14	278			1173	15	318
		1496	13	277			1496	14	307
		1820	11	278			1820	15	305
		2143	11	279			2143	12	310
		2467	14	274			2467	11	314
		2790	12	276			2790	12	317
		3114	12	286			3114	13	314
		3423	6	292			3423	14	319
		3718	8	269			3718	19	317
		4015	8	294			4015	20	316
		4312	11	294			4312	20	314
		4609	14	295			4609	20	309
		4907	15	294			4907	21	306
		5204	13	297			5204	21	302
		5501	13	297			5501	19	300
		5798	14	298			5798	20	302
		6095	16	299			6095	18	294
		6392	15	302			6392	17	295
		6689	17	298			6689	20	296
		6986	16	301			6986	18	296
		7283	16	304			7283	16	297
		7580	16	301			7580	14	294
		7877	18	301			7877	15	291
		8174	16	295			8174	14	286
		8472	17	298			8472	16	286
		8769	17	303			8769	14	281
		9066	20	308			9066	17	286
		9363	19	307			9363	17	290
		9660	19	306			9660	17	293
		9957	19	306			9957	15	294
		10254	16	311			10254	16	295
		10551	14	311			10551	17	284
		10848	19	313			10848	15	282
		11145	16	331			11145	12	278
		11442	17	335			11442	11	267
		11739	20	320			11739		
		12036	19	313			12036		
		12334	19	314			12334		
		12631	19	305			12631		
		12928	5	95			12928		
		13225	19	309			13225		
		13522	50	302			13522		

continued

Table C7. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/17/81	1100	182	--	--	7/17/81	1400	182	6	323
		526	3	314			526	9	306
		849	6	330			849	12	305
		1173	5	335			1173	10	298
		1496	5	326			1496	11	294
		1820	8	328			1820	9	305
		2143	7	312			2143	10	312
		2467	8	315			2467	8	296
		2790	8	322			2790	14	307
		3114	11	327			3114	14	306
		3423	13	322			3423	11	312
		3718	12	318			3718	8	308
		4015	14	317			4015	7	306
		4312	19	312			4312	10	292
		4609	21	310			4609	3	287
		4907	--	--			4907	7	323
		5204	22	307			5204	9	342
		5501					5501	9	351
		5798					5798	8	337
		6095					6095	9	331
		6392					6392	11	351
		6689					6689	15	333
		6986					6986	21	328
		7283					7283	25	326
		7580					7580	25	324
		7877					7877	26	321
		8174					8174	26	318
		8472					8472	28	321
		8769					8769	24	317
		9066					9066	--	--
		9363					9363	23	309
		9660					9660	21	305
		9957					9957	18	304
		10254					10254	18	303
		10551					10551	16	300
		10848					10848	19	299
		11145					11145	20	290
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C8. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/17/81	1600	182	5	302	7/20/81	0900	182	6	272
		526	7	312			526	6	289
		849	8	309			849	12	298
		1173	11	309			1173	13	310
		1496	10	310			1496	16	302
		1820	10	316			1820	15	29-
		2143	9	310			2143	12	272
		2467	9	310			2467	13	269
		2790	8	283			2790	15	265
		3114	10	295			3114	15	258
		3423	8	289			3423	16	256
		3718	11	288			3718	18	261
		4015	8	277			4015	17	261
		4312	4	265			4312	19	258
		4609	5	328			4609	20	259
		4907	10	319			4907		
		5204	2	8			5204		
		5501	8	350			5501		
		5798	10	348			5798		
		6095	13	342			6095		
		6392	13	347			6392		
		6689	13	345			6689		
		6986	16	342			6986		
		7283	16	337			7283		
		7580	15	344			7580		
		7877	17	306			7877		
		8174	17	325			8174		
		8472	17	326			8472		
		8769	16	323			8769		
		9066	15	317			9066		
		9363	19	319			9363		
		9660	15	319			9660		
		9957	15	316			9957		
		10254	14	318			10254		
		10551	15	316			10551		
		10848	17	320			10848		
		11145	18	320			11145		
		11442	17	309			11442		
		11739	16	293			11739		
		12036	18	289			12036		
		12334	18	276			12334		
		12631	20	276			12631		
		12928	19	262			12928		
		13225	19	254			13225		
		13522	18	258			13522		

continued

Table C9. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/20/81	1100	182	6	296	7/20/81	1400	182	10	306
		526	4	324			526	13	315
		849	8	312			849	11	324
		1173	10	308			1173	10	333
		1496	15	311			1496	8	334
		1820	17	314			1820	10	329
		2143	18	316			2143	10	337
		2467	15	313			2467	9	327
		2790	21	311			2790	9	306
		3114	16	303			3114	15	305
		3423	14	293			3423	9	289
		3718	15	293			3718	11	298
		4015	16	289			4015	7	291
		4312	16	282			4312	7	296
		4609	17	280			4609	12	304
		4907	16	274			4907	11	312
		5204	17	277			5204	12	303
		5501	16	278			5501		
		5798	17	280			5798		
		6095	18	278			6095		
		6392	19	278			6392		
		6689	18	277			6689		
		6986	17	279			6986		
		7283	19	281			7283		
		7580					7580		
		7877					7877		
		8174					8174		
		8472					8472		
		8769					8769		
		9066					9066		
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C10. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/20/81	1600	182	5	308	7/21/81	0900	182	10	322
		526	6	307			526	12	320
		849	7	307			849	18	326
		1173	7	303			1173	26	320
		1496	6	306			1496	29	311
		1820	5	302			1820	27	310
		2143	6	303			2143	27	312
		2467	10	310			2467	25	309
		2790	8	289			2790	26	308
		3114	11	309			3114	24	307
		3423	12	311			3423	20	307
		3718	--	--			3718	20	313
		4015	11	310			4015	22	313
		4312	14	304			4312	24	313
		4609					4609	26	308
		4907					4907	23	309
		5204					5204	26	306
		5501					5501	24	305
		5798					5798	21	309
		6095					6095	21	313
		6392					6392	21	313
		6689					6689	15	311
		6986					6986	18	309
		7283					7283	24	311
		7580					7580	28	313
		7877					7877	28	315
		8174					8174	25	316
		8472					8472	26	322
		8769					8769	34	318
		9066					9066		
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C11. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/21/81	1110	182	7	311	7/21/81	1408	182	7	294
		526	9	322			526	8	303
		849	10	326			849	14	294
		1173	10	348			1173	11	306
		1496	11	351			1496	12	319
		1820	20	343			1820	14	320
		2143	36	341			2143		
		2467	45	341			2467		
		2790	29	336			2790		
		3114	29	333			3114		
		3423	18	320			3423		
		3718	19	310			3718		
		4015	18	304			4015		
		4312	19	303			4312		
		4609	20	302			4609		
		4907	22	301			4907		
		5204	23	303			5204		
		5501	26	302			5501		
		5798	22	299			5798		
		6095	18	295			6095		
		6392	21	311			6392		
		6689	19	311			6689		
		6986	21	313			6986		
		7283	24	320			7283		
		7580	27	320			7580		
		7877	25	320			7877		
		8174					8174		
		8472					8472		
		8769					8769		
		9066					9066		
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C12. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/21/81	1600	182	15	303	7/22/81	0900	182	3	329
		526	20	301			526	4	335
		849	20	304			849	14	4
		1173	15	309			1173	15	349
		1496	15	305			1496	14	350
		1820	18	309			1820	18	348
		2143	23	314			2143	14	337
		2467	26	317			2467	15	336
		2790	29	323			2790	22	325
		3114	--	--			3114	16	329
		3423	21	320			3423	15	309
		3718	12	320			3718	13	317
		4015	14	325			4015	12	315
		4312	14	325			4312	11	317
		4609	12	328			4609	11	339
		4907	21	311			4907	12	307
		5204	32	308			5204	13	341
		5501	28	304			5501	15	304
		5798	36	300			5798	14	322
		6095	36	304			6095	15	311
		6392	33	304			6392		
		6689	30	301			6689		
		6986	22	294			6986		
		7283	28	296			7283		
		7580	19	288			7580		
		7877	23	287			7877		
		8174	33	202			8174		
		8472	21	275			8472		
		8769	26	290			8769		
		9066	23	284			9066		
		9363	27	286			9363		
		9660	27	287			9660		
		9957	18	282			9957		
		10254	18	285			10254		
		10551	22	288			10551		
		10848	22	294			10848		
		11145	27	301			11145		
		11442	27	298			11442		
		11739	22	293			11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C13. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/22/81	1100	182	--	--	7/22/81	1400	182	--	--
		526	6	332			526	5	25
		849	5	321			849	5	6
		1173	5	315			1173	5	8
		1496	9	332			1496	7	330
		1820	11	335			1820	5	322
		2143	11	342			2143	6	329
		2467	13	341			2467	5	326
		2790	13	338			2790	7	334
		3114	13	335			3114	6	337
		3423	12	331			3423	8	336
		3718	11	320			3718	9	345
		4015	8	332			4015	13	330
		4312	9	305			4312	13	335
		4609	8	329			4609	12	341
		4907	9	342			4907	13	346
		5204	9	342			5204	12	346
		5501	8	346			5501	12	346
		5798	9	345			5798	6	326
		6095	9	338			6095	18	330
		6392	10	344			6392	10	330
		6689	10	340			6689	14	323
		6986	10	330			6986	16	312
		7283					7283	16	304
		7580					7580	13	306
		7877					7877	14	310
		8174					8174	16	314
		8472					8472	16	310
		8769					8769	15	304
		9066					9066	13	304
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C14. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/22/81	1600	182	--	--	7/23/81	0900	182	15	72
		526	14	333			526	16	75
		849	24	337			849	14	88
		1173	17	335			1173	22	98
		1496	23	331			1496	23	103
		1820	18	327			1820	15	109
		2143	19	341			2143	10	115
		2467	7	330			2467	7	115
		2790	11	320			2790	4	101
		3114	5	311			3114	5	91
		3423	6	272			3423	5	76
		3718	7	256			3718	6	75
		4015	5	240			4015	7	46
		4312	7	298			4312	7	6
		4609	9	305			4609	6	7
		4907	7	289			4907	5	5
		5204	8	310			5204	6	15
		5501	10	322			5501	6	9
		5798	11	336			5798	7	356
		6095	13	357			6095	8	357
		6392	16	325			6392	10	344
		6689	21	14			6689	11	338
		6986	15	342			6986	12	335
		7283	14	337			7283	12	345
		7580	15	339			7580	13	357
		7877	19	333			7877	18	359
		8174	18	334			8174	20	351
		8472	19	329			8472	24	353
		8769	18	324			8769	24	352
		9066	15	328			9066	23	353
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C15. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/23/81	1100	182	8	77	7/23/81	1400	182	4	61
		526	8	71			526	2	119
		849	7	76			849	3	127
		1173	8	94			1173	3	66
		1496	9	122			1496	2	62
		1820	11	124			1820	2	105
		2143	8	129			2143	2	98
		2467	5	141			2467	3	91
		2790	5	127			2790	2	102
		3114	4	108			3114	2	18
		3423	5	127			3423	1	125
		3718	6	132			3718	1	334
		4015	5	113			4015	2	295
		4312	5	49			4312	2	341
		4609	4	12			4609	2	343
		4907	4	8			4907	3	0
		5204	6	8			5204	4	356
		5501	6	0			5501		
		5798	9	340			5798		
		6095	11	351			6095		
		6392	14	355			6392		
		6689	13	3			6689		
		6986	14	1			6986		
		7283	19	350			7283		
		7580	19	346			7580		
		7877	16	352			7877		
		8174	13	5			8174		
		8472	13	350			8472		
		8769	14	342			8769		
		9066	16	354			9066		
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C16. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/23/81	1600	182	6	316	7/24/81	0915	182	6	81
		526	6	306			526	5	109
		849	2	301			849	10	99
		1173	4	352			1173	6	148
		1496	4	351			1496	6	155
		1820	1	174			1820	5	146
		2143	2	282			2143	6	150
		2467	3	307			2467	8	180
		2790	3	342			2790	6	188
		3114	3	354			3114	5	213
		3423	4	346			3423	5	254
		3718	5	11			3718	6	271
		4015	1	48			4015	8	290
		4312	1	10			4312	8	288
		4609	3	345			4609	9	299
		4907	5	342			4907	8	322
		5204	7	340			5204	6	327
		5501	11	334			5501	5	312
		5798	16	333			5798	6	303
		6095	13	329			6095	7	313
		6392	10	332			6392	8	331
		6689	10	346			6689	9	328
		6986	16	348			6986	10	336
		7283	5	337			7283		
		7580	13	346			7580		
		7877	14	348			7877		
		8174	15	349			8174		
		8472	16	348			8472		
		8769	15	347			8769		
		9066	16	346			9066		
		9363	18	345			9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C17. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/24/81	1100	182	6	75	7/24/81	1400	182	3	105
		526	4	82			526	1	300
		849	4	86			849	2	337
		1173	5	126			1173	1	58
		1496	5	182			1496	3	110
		1820	10	208			1820	2	124
		2143	5	189			2143	3	190
		2467	7	217			2467	2	225
		2790	6	241			2790	0	282
		3114	6	259			3114	2	232
		3423	6	277			3423	4	197
		3718	7	304			3718	4	226
		4015	8	321			4015	5	288
		4312	8	320			4312	7	304
		4609	6	311			4609		
		4907	5	286			4907		
		5204	7	280			5204		
		5501	6	292			5501		
		5798	7	302			5798		
		6095	8	315			6095		
		6392	10	318			6392		
		6689	11	329			6689		
		6986	13	333			6986		
		7283	17	334			7283		
		7580	22	330			7580		
		7877	21	330			7877		
		8174	20	335			8174		
		8472	18	347			8472		
		8769	18	353			8769		
		9066	20	350			9066		
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C18. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/25/81	0900	182	6	347	7/25/81	1100	182	2	290
		526	5	325			526	3	302
		849	8	306			849	5	275
		1173	5	292			1173	9	288
		1496	8	315			1496	10	294
		1820	10	305			1820	11	292
		2143	11	304			2143	13	301
		2467	14	305			2467	13	308
		2790	16	294			2790	12	313
		3114	18	309			3114	13	315
		3423	18	316			3423	12	324
		3718	17	315			3718	12	328
		4015	16	310			4015	10	332
		4312	14	316			4312	9	328
		4609	15	324			4609	7	302
		4907	16	322			4907	8	291
		5204	17	319			5204	7	294
		5501	15	316			5501	10	297
		5798	17	314			5798	10	297
		6095	15	310			6095	12	302
		6392	16	311			6392	13	307
		6689	28	317			6689	13	309
		6986	4	261			6986	14	303
		7283	15	296			7283	14	296
		7580	16	296			7580	14	295
		7877	15	291			7877	14	301
		8174	15	292			8174	14	311
		8472	11	278			8472	14	324
		8769	11	279			8769	14	329
		9066	11	280			9066	19	330
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C19. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/25/81	1412	182	11	280	7/25/81	1600	182	5	331
		526	14	282			526	7	309
		849	14	281			849	7	304
		1173	16	289			1173	7	311
		1496	14	294			1496	10	323
		1820	10	295			1820	12	339
		2143	7	296			2143	13	331
		2467	6	295			2467	10	327
		2790	4	273			2790	9	332
		3114	2	252			3114	10	324
		3423	5	279			3423	7	308
		3718	5	262			3718	6	313
		4015	6	241			4015	6	314
		4312	9	249			4312	8	308
		4609	10	269			4609	9	311
		4907	8	303			4907	12	321
		5204	9	308			5204	14	327
		5501	9	293			5501	13	331
		5798	8	287			5798	11	344
		6095	9	291			6095	10	343
		6392	10	307			6392	11	337
		6689	14	313			6689	9	327
		6986	13	313			6986	9	321
		7283	15	310			7283	11	335
		7580	13	321			7580	15	334
		7877	13	326			7877	15	331
		8174	14	329			8174	14	330
		8472	13	331			8472	17	333
		8769	12	337			8769	14	333
		9066	15	341			9066	13	334
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C20. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/27/81	0900	182	6	312	7/27/81	1100	182	2	281
		526	12	290			526	3	291
		849	12	289			849	9	305
		1173	12	280			1173	13	296
		1496	14	275			1496	14	301
		1820	12	272			1820	14	298
		2143	11	272			2143	12	292
		2467	13	279			2467	1-	293
		2790	12	282			2790	9	270
		3114	10	279			3114	8	278
		3423	6	281			3423	8	254
		3718	6	281			3718	7	271
		4015	6	272			4015	9	281
		4312	3	277			4312	10	284
		4609	3	273			4609	9	286
		4907	3	250			4907	8	279
		5204	4	218			5204	6	280
		5501	6	207			5501	5	275
		5798	8	217			5798	5	255
		6095	9	219			6095	4	258
		6392	9	219			6392	5	259
		6689	8	214			6689	3	233
		6986	8	193			6986	4	178
		7283	9	174			7283	5	156
		7580	10	163			7580	9	141
		7877	13	156			7877	12	145
		8174	17	152			8174	12	136
		8472	15	143			8472	13	141
		8769	16	139			8769	15	140
		9066	18	135			9066	15	138
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C21. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/27/81	1400	182	7	308	7/27/81	1600	182	10	229
		526	8	309			526	8	223
		849	9	308			849	6	307
		1173	7	303			1173	3	193
		1496	6	299			1496	3	204
		1820	4	300			1820	4	233
		2143	1	271			2143	1	222
		2467	2	237			2467	3	253
		2790	5	257			2790	3	265
		3114	5	267			3114	4	262
		3423					3423	5	264
		3718					3718	4	292
		4015					4015		
		4312					4312		
		4609					4609		
		4907					4907		
		5204					5204		
		5501					5501		
		5798					5798		
		6095					6095		
		6392					6392		
		6689					6689		
		6986					6986		
		7283					7283		
		7580					7580		
		7877					7877		
		8174					8174		
		8472					8472		
		8769					8769		
		9066					9066		
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C22. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/28/81	0720	182	9	273	7/28/81	0809	182	8	234
		526	15	284			526	18	245
		849	17	291			849	21	260
		1173	20	299			1173	21	258
		1496	23	300			1496	22	256
		1820	20	296			1820	21	256
		2143	22	295			2143	21	258
		2467	21	297			2467	21	260
		2790	22	297			2790	20	260
		3114	19	294			3114	20	255
		3423	18	295			3423	16	253
		3718	16	295			3718	14	252
		4015	14	300			4015	13	250
		4312	11	311			4312	9	250
		4609	10	298			4609	11	246
		4907	10	287			4907	11	238
		5204	11	282			5204	12	235
		5501	11	295			5501	12	236
		5798	7	278			5798	11	236
		6095	7	276			6095	11	237
		6392					6392	9	230
		6689					6689	8	221
		6986					6986	29	176
		7283					7283	21	310
		7580					7580		
		7877					7877		
		8174					8174		
		8472					8472		
		8769					8769		
		9066					9066		
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C23. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/28/81	0900	182	6	252	7/28/81	1000	182	8	288
		526	18	260			526	8	295
		849	17	271			849	12	282
		1173	17	272			1173	16	280
		1496	18	266			1496	16	279
		1820	19	261			1820	15	274
		2143	19	259			2143	16	269
		2467	19	261			2467	17	267
		2790	18	258			2790	17	262
		3114	17	252			3114	16	255
		3423	15	252			3423	16	250
		3718	14	250			3718	15	246
		4015	14	243			4015	15	237
		4312	14	243			4312	15	237
		4609	14	241			4609	15	236
		4907	14	239			4907	15	237
		5204	16	237			5204	15	239
		5501	13	237			5501	14	241
		5798	14	237			5798	14	242
		6095	12	233			6095	12	239
		6392	14	229			6392		
		6689	13	222			6689		
		6986					6986		
		7283					7283		
		7580					7580		
		7877					7877		
		8174					8174		
		8472					8472		
		8769					8769		
		9066					9066		
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C24. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/28/81	1200	182	6	299	7/28/81	1400	182	5	264
		526	10	292			526	10	275
		849	8	285			849	12	276
		1173	8	271			1173	13	277
		1496	7	261			1496	12	271
		1820	8	272			1820	9	267
		2143	11	273			2143	11	263
		2467	11	265			2467	11	255
		2790	13	264			2790	13	242
		3114	15	268			3114	11	240
		3423	15	266			3423	11	260
		3718					3718	11	264
		4015					4015	11	256
		4312					4312	10	253
		4609					4609	9	260
		4907					4907	10	256
		5204					5204	6	223
		5501					5501	6	241
		5798					5798	7	254
		6095					6095	11	252
		6392					6392	12	254
		6689					6689	12	258
		6986					6986	16	254
		7283					7283	12	252
		7580					7580	12	251
		7877					7877	15	247
		8174					8174	19	251
		8472					8472	17	240
		8769					8769	21	242
		9066					9066	19	242
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C25. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/28/81	1600	182	15	260	7/29/81	0900	182	4	306
		526	12	249			526	8	307
		849	17	251			849	13	315
		1173	16	251			1173	12	320
		1496	19	245			1496	13	315
		1820	17	249			1820	16	309
		2143	18	257			2143	22	298
		2467	18	258			2467	24	285
		2790	16	261			2790	24	285
		3114	13	251			3114	25	285
		3423	14	251			3423	24	280
		3718	15	250			3718	23	277
		4015	14	251			4015	24	273
		4312	16	258			4312	25	272
		4609	21	259			4609	25	270
		4907	17	267			4907	24	270
		5204	18	267			5204	26	272
		5501	21	261			5501	24	274
		5798	20	254			5798	24	274
		6095	21	252			6095	21	271
		6392	19	250			6392	19	268
		6689	18	245			6689	21	271
		6986	18	252			6986	21	272
		7283	14	249			7283	19	267
		7580	16	249			7580	17	258
		7877	14	251			7877	19	262
		8174	12	250			8174	19	266
		8472	14	254			8472	19	268
		8769	16	263			8769	19	264
		9066	16	257			9066	19	263
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C26. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/29/81	1100	182	6	284	7/29/81	1400	182	10	267
		526	5	298			526	8	278
		849	5	303			849	9	267
		1173	3	312			1173	10	262
		1496	9	299			1496	4	245
		1820	13	294			1820	9	268
		2143	18	296			2143	10	278
		2467	21	279			2467	12	287
		2790	22	281			2790	13	297
		3114	23	282			3114	15	288
		3423	23	279			3423	15	287
		3718	24	279			3718	17	299
		4015	23	278			4015	16	290
		4312	24	278			4312	19	287
		4609	22	277			4609	20	282
		4907	22	275			4907	22	280
		5204	21	272			5204	21	276
		5501	23	272			5501	22	275
		5798	22	275			5798	21	276
		6095	22	272			6095	20	276
		6392	22	273			6392		
		6689	23	274			6689		
		6986	19	271			6986		
		7283	16	262			7283		
		7580	17	278			7580		
		7877	18	265			7877		
		8174	23	265			8174		
		8472	20	267			8472		
		8769	21	264			8769		
		9066	21	258			9066		
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C27. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/29/81	1600	182	8	338	7/30/81	0900	182	5	040
		526	18	330			526	12	052
		849	21	331			849	19	060
		1173	20	343			1173		
		1496	14	312			1496		
		1820	12	4			1820		
		2143	10	321			2143		
		2467	8	314			2467		
		2790	5	300			2790		
		3114	7	282			3114		
		3423	9	292			3423		
		3718	11	283			3718		
		4015	12	272			4015		
		4312	14	273			4312		
		4609	14	274			4609		
		4907	13	274			4907		
		5204	13	267			5204		
		5501	13	267			5501		
		5798	14	274			5798		
		6095	18	279			6095		
		6392	17	277			6392		
		6689	15	271			6689		
		6986	17	269			6986		
		7283	18	272			7283		
		7580	17	274			7580		
		7877	17	278			7877		
		8174	16	275			8174		
		8472	18	275			8472		
		8769	20	275			8769		
		9066	18	274			9066		
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Table C28. Upper Level Winds at Dekalb-Peachtree Airport.

Date	Time	ALT (ft)	WS (mph)	WD (deg)	Date	Time	ALT (ft)	WS (mph)	WD (deg)
7/30/81	1100	182	15	068			182		
		526	16	076			526		
		849	17	074			849		
		1173	17	081			1173		
		1496					1496		
		1820					1820		
		2143					2143		
		2467					2467		
		2790					2790		
		3114					3114		
		3423					3423		
		3718					3718		
		4015					4015		
		4312					4312		
		4609					4609		
		4907					4907		
		5204					5204		
		5501					5501		
		5798					5798		
		6095					6095		
		6392					6392		
		6689					6689		
		6986					6986		
		7283					7283		
		7580					7580		
		7877					7877		
		8174					8174		
		8472					8472		
		8769					8769		
		9066					9066		
		9363					9363		
		9660					9660		
		9957					9957		
		10254					10254		
		10551					10551		
		10848					10848		
		11145					11145		
		11442					11442		
		11739					11739		
		12036					12036		
		12334					12334		
		12631					12631		
		12928					12928		
		13225					13225		
		13522					13522		

continued

Appendix D

Meteorological Data Collected at Georgia Tech

(Data Provided by Georgia Tech)

```
                         ATLANTA (GA TECH)      YEAR 1981     MONTH  8

                                          RAINFALL .1 MM

D                                                      HOUR
A    1    2    3    4    5    6    7    8    9   10   11   12   13   14   15   16   17   18   19   20   21   22   23   24  TOTL  HR
Y   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --  ----  --

 1   0    0    0    0    0    0    0    0    0    7    0    0    5    3   12    0    0    0    0    0    0    3    0    0   30. 24
 2   0    0    0    0    0    0    0    0    0  10*    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0.$23
 3   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0. 24
 4   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0   7*    0    0.$23
 5   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0   4*    0    0.$23
 6   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0   3%    0    6    0    0    0   28   21    0   58. 24
 7   0    0    0    0    0    5   15    0    0    0    0    0    0    0   31    9    0    0    0    0    0    0    0    0   60. 24
 8   0    0    0    0    0    0    0   9*    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0.$23
 9   0    0    0    0    0    0   0*    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0.$23
10   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0   42    0    6    0    0    0    0    0   48. 24
11   0    0    0    0    0    0   16    0    0    0    0    0    0    0    0   18    0    0    0    7    0    0    0    0   41. 24
12   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0. 24
13   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0   3*    0    0    0    0    0    0    0    0    0.$23
14   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0. 24
15   0    0    0    0    0    0    0    0    0    0    0    0    0    0    9   31    5    0    0    0    0    0    0    0   45. 24
16   0   3*    0    0    0    0  10*    0    0    0    0    0    0    0   0*   0*   0*    0    0   0*    0   8*    0    0    0.$17
17  5*    0    0    0    0    0    0   8*    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0.$22
18   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0. 24
19   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0. 24
20   0    0    0    0    0    0   0*    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0.$23
21   0    0   3%    0   12   33    7    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0   55. 24
22   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0. 24
23   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0. 24
24   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0. 24
25   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0. 24
26   0    0    0    0    0    0    0    0    0    0   0*    0    0    0    0    0    0    0    0    0    0    0    0    0    0.$23
27   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0. 24
28   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0. 24
29   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0. 24
30   0    0    3    0    0    0    0   19    0   3%    3    0    0    5    0    0    0    0    0    0    0    0    0    0   32. 24
31   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0. 24
-- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- -----
AV  0$   0$    6    0   12   39  37$  19$    0  10$   3$    0    5    8  50$  61$  47$    6    6   7$    0  31$  21$    0  387.9

HR  30   30   31   31   31   31   28   29   31   30   30   31   31   31   30   29   30   31   31   30   31   30   29   31    727

----------
FLAGS:
% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS
* - BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS
$ - ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
    OR BY SUMMATIONS HAVING UNAVAILABLE HOURS
```

```
                                   ATLANTA (GA TECH)      YEAR 1981     MONTH  7
                                                   RAINFALL (.1) MM
 D                                                                HOUR
 A    1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    17    18    19    20    21    22    23    24   TOTL  HR
 Y   --    --    --    --    --    --    --    --    --    --    --    --    --    --    --    --    --    --    --    --    --    --    --    --   ----  --

 1    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     8     0     0      8. 24
 2    0     0     9    10     7    67    24    14    16     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0    147. 24
 3    0     0     0     0     0     0     0     0     0     0     0     0     0     0    54#   14     0     0     0     0     0     0     0     0     14.S23
 4    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0      0. 24
 5    0     0     0     0     0     0     0     0     0     0     0     9%    0     0   197%    8     0     0     0     0     0     0     0     0    214. 24
 6    0     0     0     0     0     0     0     0     0     0     0     0     0    11    14    32     0     0     0    12     3     0     0     0     72. 24
 7    0     0     0     0     0     0     0     0     5#    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0      0.S23
 8    0     0     0     0     0     0     0     0     0     0     0     0     3#    0     0     0     0     0     0     0     0     0     0     0      0.S23
 9    0     0     0     0     0     0     0     0     0     0     4#    0     4#    0     0     0     0     0     0     0     0     0     0     0      0.S22
10    0     0     0     0     0     0     0     3#    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0      0.S23
11    0     0     0     0     0     0     0     0     0     0     3#    0     0     0     0     0     0     0     0     0     0     0     0     0      0.S23
12    0     0     0     3#    0     0     0     0     0     0     0     0     0     0     7#    0     0     0     0     8#    0     0     0     0      0.S21
13    0     0     0     0     0     0     0     0   353#    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0      0.S23
14    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0      0. 24
15    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0      0. 24
16    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     6#    0     0     0      0.S23
17    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0      0. 24
18    0     0     0     0     0     0     4#    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0      0.S23
19    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0      0. 24
20    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0      0. 24
21    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0      0. 24
22    0     0     0     0     0     0     0     0     0     0     0     0     0     4#    0     0     0     0     0     0     0     0     0     0      0.S23
23    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0      0. 24
24    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     7#    0     0      0.S23
25    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0      0. 24
26    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0    48%    0     0     0     0     0     0     0     48. 24
27    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0      0. 24
28    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0      0. 24
29    0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0      0. 24
30    0     0     0     0     0     0     0     0     0     0     0     0     0     3#    0     0     0     0     0     0     0     0     0     0      0.S23
31    0     0     0     0     0    55    30     0    12     3     0     0     0     0     0     0     0     0     0     0     0     0     0     0    101. 24
-- ---- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ------
AV    0     0     9    10S    7   122    54S   14S   28S    3     0S    9     0S   11S  211S   54    48     0     0    12S    3S    8S    0     0    601.3

HR   31    31    31    30    31    31    30    30    29    31    29    31    29    29    29    31    31    31    31    30    30    30    31    31        728

----------
FLAGS:
% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS
# - BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS
S - ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
    OR BY SUMMATIONS HAVING UNAVAILABLE HOURS
```

ATLANTA (GA TECH)   YEAR 1981   MONTH 8

ULTRAVIOLET KJ/M2

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTL	HR
1	0	0	0	0	0	0	0%	5%	10%	13%	24%	35%	47%	56%	36%	37%	22%	11%	0%	0	0	0	0	0	297.	24
2	0	0	0	0	0	0	0%	12%	47	62$	78	97	80	69	132	121	63	34%	13%	0%	0	0	0	0	809.	24
3	0	0	0	0	0	0	4%	18	45	79	132	116	139	147	143	114	80	46	18	0%	0	0	0	0	1082.	24
4	0	0	0	0	0	0	8%	34	70	101	120	131	84%	82	129	92	30	27%	6	0	0	0	0	0	914.	24
5	0	0	0	0	0	0	6%	31	64	99	129	108	85	94	114	99	69	36	10%	0%	0	0	0	0	944.	24
6	0	0	0	0	0	0	6	24	62	102	120	103	120	142	91%	12%	65	47	13	0	0	0	0	0	907.	24
7	0	0	0	0	0	0	6	33	71	100	130	160	166	93%	10%	84	36%	14%	5%	0	0	0	0	0	908.	24
8	0	0	0	0	0	0	1%	26	33	45	80	68	71%	55%	51%	45%	62	33%	16	0	0	0	0	0	586.	24
9	0	0	0	0	0	0	15$	31	55	74	101	139	163	115	99	100	53	36	13	0	0	0	0	0	994.	24
10	0	0	0	0	0	0	2%	14	54	67	112	123	130	139	68	18%	1%	4%	9%	0	0	0	0	0	742.	24
11	0	0	0	0	0	0	6%	35	66	82	96	134	117	63%	64%	47%	29%	11%	0%	0	0	0	0	0	751.	24
12	0	0	0	0	0	0	3	25%	64	96	130	140	129	125	118	103	75	45	16	0	0	0	0	0	1068.	24
13	0	0	0	0	0	0	2%	23	53	71	89	107	114	100	81	60	41	22	6%	0	0	0	0	0	770.	24
14	0	0	0	0	0	0	5	27	53	59	95	79	93	74	45	79	56	30	10	0	0	0	0	0	702.	24
15	0	0	0	0	0	0	4	25	57	91	121	136	149	77	52%	24%	64	31	10%	0	0	0	0	0	841.	24
16	0	0	0	0	0	0	5	30	59	99	112	101	131	93	47*	49*	57*	27	5%	2$	0	0	0	0	99999.*	21
17	0	0	0	0	0	0	3%	25	44	62	81	75	89	126	103	74	44%	12%	3%	0	0	0	0	0	740.	24
18	0	0	0	0	0	0	0	6%	12%	20%	26%	34%	37%	74	50	47	27%	11%	2%	0	0	0	0	0	347.	24
19	0	0	0	0	0	0	2%	14%	44	101	113	168	101	81	89	78	60	28	8%	0	0	0	0	0	884.	24
20	0	0	0	0	0	0	6$	13	31	63	105	112	107	129	68	39	23%	23	8%	0	0	0	0	0	728.	24
21	0	0	0	0	0	0	0%	11%	42	84	95	119	69%	40%	36%	39%	47	17%	5%	0	0	0	0	0	604.	24
22	0	0	0	0	0	0	5	34	74	114	139	166	140	163	145	102	68	24%	8%	0	0	0	0	0	1183.	24
23	0	0	0	0	0	0	3	25	49	45	67	86	95	59	66	62	63	42	11%	0	0	0	0	0	674.	24
24	0	0	0	0	0	0	3	28	62	95	128	152	126%	128%	109	22%	44%	31%	9	0	0	0	0	0	935.	24
25	0	0	0	0	0	0	3%	28	59	88	120	111	140	127	108	70	60	34	10	0	0	0	0	0	960.	24
26	0	0	0	0	0	0	2	18	47	69	96$	123	118	110	110	82	54	27%	9%	0	0	0	0	0	865.	24
27	0	0	0	0	0	0	3	26	58	97	129	150	158	136	124	102	68	38	9	0	0	0	0	0	1097.	24
28	0	0	0	0	0	0	4	24	63	95	121	149	155	117	93	62%	38	26	8%	0	0	0	0	0	954.	24
29	0	0	0	0	0	0	1%	15	38	58	59	59	81	67	89	72%	48%	26	9	0	0	0	0	0	622.	24
30	0	0	0	0	0	0	0%	11%	24%	57%	110	110	125	108%	133	114	58	34	9	0	0	0	0	0	892.	24
31	0	0	0	0	0	0	3	26	38	81	112	121	84	75	134	100%	43%	28	9	0	0	0	0	0	853.	24
AV	0	0	0	0	0	0	4	22	50	76	102	113	111	99	90$	70$	50$	28	9	0	0	0	0	0	823.8	
HR	31	31	31	31	31	31	31	31	31	31	31	31	31	31	30	30	30	31	31	31	31	31	31	31		741

FLAGS:
% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS
* - BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS
$ - ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

```
                    ATLANTA (GA TECH)      YEAR 1981      MONTH  7

                                     ULTRAVIOLET KJ/M2
D                                                    HOUR
A    1    2    3    4    5    6    7    8    9   10   11   12   13   14   15   16   17   18   19   20   21   22   23   24  TOTL  HR
Y   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --  ----  --

 1   0    0    0    0    0    0   7%   33   64   70   96   71  103  110   56   32   30  10%   5$   0%   0    0    0    0   687.  24
 2   0    0    0    0    0    0   1$   1%   9%  12%  41%  55   47   79   57   37   48   45   6%   0%   0    0    0    0   439.  24
 3   0    0    0    0    0    0   0%   4%  24   70   77   67   84   73   56$  38   45   34   11   0    0    0    0    0   585.  24
 4   0    0    0    0    0    0   8%  27   59%  65  102  148  118  160   93   94   80  40%  23   1%   0    0    0    0  1018.  24
 5   0    0    0    0    0    0   5%  19   54%  62  120  121% 122% 125%  30%  85   59   26   12   0%   0    0    0    0   839.  24
 6   0    0    0    0    0    0   2%  17   47   66  104  138   93% 124   30%  40%   8%  17%   1%   0%   0    0    0    0   687.  24
 7   0    0    0    0    0    0  13   44%  81% 117  147  161  158  126   98   80   71   28    8   0%   0    0    0    0  1132.  24
 8   0    0    0    0    0    0  12   42   79  114  147  162  175  165  137% 115   83   49   19%   1   0    0    0    0  1298.  24
 9   0    0    0    0    0    0   7%  27   56   94  117  145  163  152  143  111%  85   51   20    0   0    0    0    0  1171.  24
10   0    0    0    0    0    0   9%  34   69  103  126  149  157  150  109  100   68   45   19    0   0    0    0    0  1139.  24
11   0    0    0    0    0    0  10   34   63   93  112  127  148  150  129   93   57   35    7%  0%   0    0    0    0  1057.  24
12   0    0    0    0    0    0   9%  31   58   88  104  117  141  136  132  105   78   49   15    0   0    0    0    0  1061.  24
13   0    0    0    0    0    0   8   33   62  101  128  142  142  127  122  104   79   45   18   0%   0    0    0    0  1111.  24
14   0    0    0    0    0    0   6%  27   68  107  134  152  162  143  132  106   74   43   18   0%   0    0    0    0  1173.  24
15   0    0    0    0    0    0   7%  31   62  103  120  143  141  152   47%  67   39   22    4    0   0    0    0    0   940.  24
16   0    0    0    0    0    0   9   36   71  102  116  114  119% 156  151  119   85   52   20    0   0    0    0    0  1150.  24
17   0    0    0    0    0    0  10   36   67  104  133  138  123% 118% 103%  93   69   41%   7%  0%   0    0    0    0  1041.  24
18   0    0    0    0    0    0   7%  35   71   94  103  154  156  142  113   89   72   45   19   0%   0    0    0    0  1100.  24
19   0    0    0    0    0    0   8%  34   66  100  124  116  111  132  115   97%  73%  47   16%  0%   0    0    0    0  1040.  24
20   0    0    0    0    0    0   7%  31   60   91  110  123  123   85%  129  103%  73%  49   21    0   0    0    0    0  1004.  24
21   0    0    0    0    0    0  10%  40%  77  116  147  172  175  166  145  113   85   50   19    0   0    0    0    0  1317.  24
22   0    0    0    0    0    0   8   36   70  106  138  170  178  164  144  122   88   50   20    0   0    0    0    0  1295.  24
23   0    0    0    0    0    0   9   37   72  108  137  159  166  164  132  104   78   45   17    0   0    0    0    0  1227.  24
24   0    0    0    0    0    0   7   31   64   97  113  142  142  136   72%  68   51   32   13   0%   0    0    0    0   967.  24
25   0    0    0    0    0    0   3%  16   63   94  124  145   82   65  102   81   74   43   19%  0%   0    0    0    0   912.  24
26   0    0    0    0    0    0   7   32   59   91  115  137  141  122   98   48%  15%  13   14%   0   0    0    0    0   893.  24
27   0    0    0    0    0    0   6   32   48   69   88  116  129   93  107   98%  62%  35%  17   0%   0    0    0    0   902.  24
28   0    0    0    0    0    0   6%  34   67  103  136  154  140% 139  138  107   77   42%  13%   0   0    0    0    0  1156.  24
29   0    0    0    0    0    0   7%  33   53   58   82   96  168  133%  72%  16%   7%   1%   3%  0%   0    0    0    0   729.  24
30   0    0    0    0    0    0   2%  17%  43%  32%  45% 138  133  125  134  109   80   32   12%  0%   0    0    0    0   900.  24
31   0    0    0    0    0    0   1$   2%  12%  17%  22%  39%  41%  42%  40%  31%  23%  15%   1%  0%   0    0    0    0   285.  24
-- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- -----
AV   0    0    0    0    0    0    7   29   59   85  110  129  132  128  102   84   62   38   13    0    0    0    0    0   976.

HR  31   31   31   31   31   31   31   31   31   31   31   31   31   31   31   31   31   31   31   31   31   31   31   31         744

----------
FLAGS:
% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS
# - BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS
$ - ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
    OR BY SUMMATIONS HAVING UNAVAILABLE HOURS
```

```
                      ATLANTA (GA TECH)     YEAR 1981     MONTH 8
                                   AVAILABLE SUNSHINE %
D                                                  HOUR
A   1    2    3    4    5    6    7    8    9   10   11   12   13   14   15   16   17   18   19   20   21   22   23   24    AVG  HR
Y  --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   ----  --
1   0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0      0. 24
2   0    0    0    0    0    0    0    0    0    0   0X   0X    0   6X  46X   70  25X   2X    0    0    0    0    0    0     11. 24
3   0    0    0    0    0    0    0    0   1X  17X   86  49X  65X  89X   93   95  100  100   53    0    0    0    0    0     55. 24
4   0    0    0    0    0    0   38   95  100   98  82X  79X  33X  34X   92  78X   2X   0X   0X   0X    0    0    0    0     54. 24
5   0    0    0    0    0   0X   0X  39X  100  100  100  54X  18X  21X  80X  78X  88X  97X  13X   0X    0    0    0    0     58. 24
6   0    0    0    0    0   0X   0X   0X  63X  100  61X  41X  38X  74X  39X   0X  33X  80X   0X   0X    0    0    0    0     39. 24
7   0    0    0    0    0   0X   0X  65X   98   82  83X   97   96  33X   0X  22X   0X   0X   0X   0X    0    0    0    0     43. 24
8   0    0    0    0    0   0X   0X   0X   0X   0X   4X   0X   2X   3X   2X   0X  44X  18X   0X   0X    0    0    0    0      5. 24
9   0    0    0    0    0   0X    0   7X   5X  23X  25X  78X  100  43X  27X  79X  30X   0X   0X   0X    0    0    0    0     31. 24
10  0    0    0    0    0   0X   0X   0X  13X   2X   6X   9X  30X  68X   3X   0X   0X   0X   0X   0X    0    0    0    0     10. 24
11  0    0    0    0    0    0   0X  77X  75X  37X  32X  83X  40X   2X   4X   3X   0X   0X   0X   0X    0    0    0    0     26. 24
12  0    0    0    0    0    0   0X   7X  58X  77X  80X  86X  64X  73X  80X  88X  83X   98  37X   0X    0    0    0    0     62. 24
13  0    0    0    0    0    0   0X   0X  55X 100X 100X 100X  64X  52X  41X  33X   8X   0X   0X   0X    0    0    0    0     41. 24
14  0    0    0    0    0    0   0X  38X  100  42X  76X  22X  47X  28X   0X  56X  63X   4X   0X   0X    0    0    0    0     36. 24
15  0    0    0    0    0    0   0X   7X  94X  100  100  87X   90  32X  15X   0X   0X   0X   0X   0X    0    0    0    0     39. 24
16  0    0    0    0    0    0   0X  36X  67X   98  48X  11X  64X  27X   0*   0*   0*   0X   0X   0$    0    0    0    0  99999.*21
17  0    0    0    0    0    0   0X   0X   0X   1X   0X   0X   0X   6X   5X   0X   0X   0X   0X   0X    0    0    0    0      1. 24
18  0    0    0    0    0    0   0X   0X   0X   0X   0X   0X   0X   0X   0X   0X   0X   0X   0X   0X    0    0    0    0      0. 24
19  0    0    0    0    0    0   0X   0X   0X  30X   9X  68X   0X   0X   0X   2X  19X   0X   0X   0X    0    0    0    0     10. 24
20  0    0    0    0    0    0    0   0X   0X   0X   0X   7X   6X  29X   0X   0X   0X   0X   0X   0X    0    0    0    0      3. 24
21  0    0    0    0    0    0   0X   0X   0X   5X   0X   7X   0X   0X   0X   0X   0X   0X   0X   0X    0    0    0    0      1. 24
22  0    0    0    0    0    0  37X  100  100  100  82X  79X  40X  89X  69X  58X  59X   0X   0X   0X    0    0    0    0     62. 24
23  0    0    0    0    0    0   0X   0X   0X   0X   0X   0X   2X   0X   0X   0X  35X  60X  20X   0X    0    0    0    0      9. 24
24  0    0    0    0    0    0   0X  68X  100  100  100   94  55X  57X  58X   0X  13X  19X   0X   0X    0    0    0    0     51. 24
25  0    0    0    0    0    0   0X  67X   98  99X   98  67X   97  85X  53X  42X  63X  100   5X   0X    0    0    0    0     67. 24
26  0    0    0    0    0    0   0X   0X   0X   4X   30  28X  15X  27X  60X  48X   6X   0X   0X   0X    0    0    0    0     17. 24
27  0    0    0    0    0    0   0X   0X  69X  100  100  100   97  78X  82X  81X  93X  43X   0X   0X    0    0    0    0     65. 24
28  0    0    0    0    0    0   0X   5X  61X  80X  79X   90  82X  39X  28X   2X   0X   0X   0X   0X    0    0    0    0     36. 24
29  0    0    0    0    0    0   0X   0X   0X   0X   0X   0X   0X  10X  22X  12X   4X  18X   2X   0X    0    0    0    0      5. 24
30  0    0    0    0    0    0   0X   0X   0X   0X   7X  20X  31X  23X  59X   97  50X  87X  27X   0X    0    0    0    0     31. 24
31  0    0    0    0    0    0  28X  42X   0X  15X  45X  47X  12X   4X  87X  79X  18X  22X   1X   0X    0    0    0    0     31. 24
-- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- -----
AV  0    0    0    0    0    0    3   21   41   45   48   45   38   33  35$  34$  28$   24    5    0    0    0    0    0   30.8

HR 31   31   31   31   31   31   31   31   31   31   31   31   31   31   30   30   30   31   31   31   31   31   31   31     741

-----------
FLAGS:
% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS
* - BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS
$ - ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
    OR BY SUMMATIONS HAVING UNAVAILABLE HOURS


GT 3% ERROR IN MONTHLY AVG:
DAILY AVG =   27.
```

ATLANTA (GA TECH)   YEAR 1981   MONTH 7

AVAILABLE SUNSHINE %

HOUR

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVG	HR
1	0	0	0	0	0	0%	0%	37%	94%	9%	24%	13%	32%	26%	0%	0	0	0	0	0%	0	0	0	0	17.	24
2	0	0	0	0	0	0%	0	0	0%	0%	0%	0%	0%	1%	0%	0	4%	6%	0	0%	0	0	0	0	1.	24
3	0	0	0	0	0	0%	0	0%	0%	1%	1%	0%	0%	2%	0	0	0%	0%	0	0%	0	0	0	0	0.	24
4	0	0	0	0	0	0%	0%	0%	9%	5%	26%	69%	30%	92%	16%	47%	62%	26%	15%	0%	0	0	0	0	28.	24
5	0	0	0	0	0	0%	0	0	16%	18%	49%	36%	31%	48%	1	20	5%	0	0	0%	0	0	0	0	16.	24
6	0	0	0	0	0	0%	0	0	1	1%	10%	52%	13%	41%	0	0	0	3	0	0%	0	0	0	0	9.	24
7	0	0	0	0	0	0%	90	100%	100%	100	100	89	78%	51%	45%	34%	49%	12%	0	0%	0	0	0	0	60.	24
8	0	0	0	0	0	0%	63%	100	100	100	100	92	97	96	78%	88	98	74%	6%	0%	0	0	0	0	77.	24
9	0	0	0	0	0	0%	0%	0%	0%	59%	91	89	93	83%	91	83%	90	100	44%	0%	0	0	0	0	58.	24
10	0	0	0	0	0	0%	27%	100	100	100	100	100	97	99	77%	83%	57	98	65%	0%	0	0	0	0	78.	24
11	0	0	0	0	0	0%	0%	68%	93	100	80%	60%	100	100	96%	48%	0%	0%	0%	0%	0	0	0	0	53.	24
12	0	0	0	0	0	0%	0%	0%	8%	100%	74%	57%	82%	83%	84%	82%	62%	26%	0%	0%	0	0	0	0	47.	24
13	0	0	0	0	0	0%	0%	37%	82%	100	90	76%	73%	68%	78%	93%	100	56%	0%	0%	0	0	0	0	61.	24
14	0	0	0	0	0	0%	0%	10%	92	100	91	93	96%	79%	91	89	96	93%	0%	0%	0	0	0	0	66.	24
15	0	0	0	0	0	0%	0%	19%	79%	100	80%	77%	70%	91	16	3%	0%	0%	0%	0%	0	0	0	0	38.	24
16	0	0	0	0	0	0%	5%	100	100	99	78%	49%	46%	85%	96	95	97	99	76%	0%	0	0	0	0	73.	24
17	0	0	0	0	0	0%	58%	100	100	100	90	73%	50%	50%	43%	67%	89	75%	0	0%	0	0	0	0	64.	24
18	0	0	0	0	0	0%	2%	26%	76%	44%	37%	78%	69%	69%	55%	50%	46%	73%	11	0%	0	0	0	0	45.	24
19	0	0	0	0	0	0%	0	63	100%	100	92	52%	57	67%	70%	65%	83%	98	43	0%	0	0	0	0	64.	24
20	0	0	0	0	0	0%	0	46	97	77%	49%	53%	46%	24%	70%	67%	73%	86%	85	0%	0	0	0	0	55.	24
21	0	0	0	0	0	0%	64	82	100	100	100	100	100	100	90	90	100	100	100	22%	0	0	0	0	83.	24
22	[illegible]	0	0	0	0	0%	67	100	100	100	96	100	100	100	100	100	100	100	100	24%	0	0	0	0	92.	24
23	[illegible]	0	0	0	0	0%	61	100	100	100	100	100	100	100	96	93	100	100	58	0%	0	0	0	0	87.	24
24	[illegible]	0	0	0	0	0%	0	82	100	84%	72%	100	100	100	24%	48%	72%	39%	2%	0%	0	0	0	0	59.	24
25	0	0	0	0	0	0%	0	0	50%	33%	42%	56%	1%	0%	8%	1%	89%	96	64	0%	0	0	0	0	32.	24
26	0	0	0	0	0	0%	0	84	100	100	100	100	95%	72%	61%	18	0	0%	0%	0%	0	0	0	0	53.	24
27	0	0	0	0	0	0%	0	77%	18%	2%	2%	21%	23%	2%	51%	84	62%	38%	12%	0%	0	0	0	0	28.	24
28	0	0	0	0	0	0%	0%	80	100	100	97	90	68%	73%	92	92	92	72	0%	0%	0	0	0	0	69.	24
29	0	0	0	0	0	0%	33	58%	8%	0%	0%	0%	75%	51%	11%	0	0	0	0	0%	0	0	0	0	17.	24
30	0	0	0	0	0	0%	0	0	1%	0	0	22%	29%	11%	23%	22%	48%	0	0	0%	0	0	0	0	12.	24
31	0	0	0	0	0	0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0%	0	0	0	0	0.	24
AV	0	0	0	0	0	0	15	47	62	62	60	61	60	60	50	51	54	47	22	2	0	0	0	0	47.	
HR	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31		744

FLAGS:
% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS
# - BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS
$ - ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

GT 3% ERROR IN MONTHLY AVG:
DAILY AVG = 44.

ATLANTA (GA TECH)   YEAR 1981   MONTH 8

DEWPOINT .1 DEG.C

DAY	HOUR 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVG	HR
1	173	174	176	176	174	173	173	175	177	180	185	189	194	195	195	196	194	192	189	186	182	182	181	180	183.	24
2	178	178	178	178	179	179	181	185	189	194$	199	203	203	205	207	207	203	203	204	208	208	209	209	208	196.	24
3	208	209	208	207	205	206	208%	214%	216	218	217	212	201	191	183	178	179	179	179	180	187	190	199	207	199.	24
4	206	209	209	209	210	209	209	215	220	220	213	206	203	200	202	192	187	189	191	208	212	213	212	213	208.	24
5	215	218	217	215	216	216	218	222	225	224	220	211	205	205	203	201	198	200	208	213	209	207	208	209	212.	24
6	209	207	204	207	209	211	214	217	222	228	232	234	229	229	228	218	237	235	217	217	212	204	206	209	218.	24
7	209	207	206	207	211	217	218	223	226	229	229	221	217	211	222	229	227	229	230	215	222	218	213	214	219.	24
8	215	214	214	216	217	217	217	216	217	218	219	219	219	223	221	222	219	216	220	218	232	230	228	225	220.	24
9	224	221	217	216	215	214	215$	216	222	224	223	206	194	197	180	172	194%	215	219	205	204	210	212	213	209.	24
10	208	205	207	208	208	209	211	216	220$	224	228	230	229	225	221	219	213	208	210	215	217	218	216	209	216.	24
11	207	206	204	206	205	206	205	210	219	226	224	224	218	230	224	207	208	204	217	214	205	204	206	206	212.	24
12	204	204	204	203	200	202	203	203	206	214	215	215	209	207	202	194	190	185	194	202	206	210	205	203	203.	24
13	204	210	200	202	206	205	204	205	209	212	214	209	204	198	194	190	191	199	210	210	209	211	211	213	205.	24
14	216	218	217	216	213	211	210	212	220	219	214	202	196	191	186	179	170	172	182	187	186	194	198	198	200.	24
15	194	204	205	204	204	204	204	209	215	215	212	211	207	204	203	211	211	210	204	209	207	209	212	212	208.	24
16	212	214	213	215	216	217	217	222	226	229	226	225	229	229	203*	209*	216*	218	212	217$	222	224	217	220	219.$	21
17	213	210	210	212	212	212	213	216	222	226	226	226	225	222	217	216	213	210	206	200	194	192	190	188	211.	24
18	183	179	177	177	178	177	176	176	174	171	170	167	164	155	156	158	157	151	137	136	138	140	142	139	162.	24
19	141	149	153	156	156	155	153	152	153	158	163	169	168	169	172	174	175	175	174	173	166	162	161	161	162.	24
20	160	160	158	157	158	156	156$	156	156	156	163	168	173	178	177	177	179	180	179	185	192	189	185	187	170.	24
21	185	189	190	191	188	179	177	174	172	167	165	164	161	160	161	163	167	171	175	172	171	165	159	162	172.	24
22	163	164	161	155	144	134	130	134	145	155	158	161	162	156	155	155	155	161	165	165	167	170	176	174	157.	24
23	173	170	176	179	182	180	180	182	184	182	181	181	184	178	178	178	183	183	183	183	174	173	179	179	179.	24
24	179	179	177	176	176	174	177	180	178	183	191	194	190	182	178	175	184%	184	179	176	188	199	198	197	183.	24
25	194	194	192	190	187	185	183	182	183	195	204	202	198	181	169	188	192	182	181	181	184	191	195	193	189.	24
26	191	189	185	186	185	184	186	191	189	189	186$	183	168	163	164	164	165	173	180	184	179	178	179	180	180.	24
27	179	180	180	179	177	175	174	178	179	176	163	162	155	147	140	139	139	143	154	154	148	151	153	156	162.	24
28	159	161	161	161	162	161	160	161	169	181	174	167	169	171	165	161	161	168	174	180	185	189	190	191	170.	24
29	193	197	196	197	188	187	191	198	202	203	204	203	205	205	208	205	201	201	203	201	203	204	205	205	200.	24
30	204	202	203	203	203	203	202	204	208	210	213	212	209	216	212	207	199	201	195	197	195	200	202	204	204.	24
31	208	206	205	204	202	200	199	200	204	207	208	207	205	202	202	197	198	203	203	198	196	199	197	199	202.	24
AV	194	194	194	194	193	192	192	195	198	201	201	199	197	194	191$	189$	190$	192	193	193	194	195	195	195	194.$	
HR	31	31	31	31	31	31	31	31	31	31	31	31	31	31	30	30	30	31	31	31	31	31	31	31		741

FLAGS:

% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS

* - BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS

$ - ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH)   YEAR 1981   MONTH 7

DEWPOINT .1 DEG.C

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVG	HR
1	171	177	176	176	176	176	178	180	178	173	174	174	181	179	179	182	176	172	178	181	188	192	189%	169	178.	24
2	168	168	171	181%	185%	178%	165	173%	179%	185%	188	191	192	192	189	187	186%	153	156	166	163	165	178	188	177.	24
3	187	188	187	189	191	191	191	193	193	195	194	191	190	190	196$	203	210	208	203	203	205	202	200	200	196.	24
4	196	191	191	186	182	181	184	187	189	192	194	195	189	185	186	193	190%	185%	188%	189%	192%	196%	199	203	190.	24
5	208	210	214	216%	216%	217	218	218	216	216	216	214	226	224	208	211	214	213	202	204	209	211	201	197	212.	24
6	196	198%	200%	201%	200%	201%	205%	211%	214%	216%	217%	215%	218%	226%	223	228%	210	216	221%	224%	218	213	209	208	212.	24
7	206%	205%	204%	201%	198%	195	193	200	211	221	216	208	207	206	208	209	207	207	211	218	223	219	225	226	209.	24
8	224	225	224	222	221	221	222	219	218	209	208	204	206	208	208	203	203	202	203	209	214	213	213	213	213.	24
9	212	209	209	210	211	212	212	214	219	221	220	210	207	200	188	195	193	223	219	220	213	210	207	205	210.	24
10	209	206	205	209	209	209	211	214	218	221	217	201	199	197	201	203	210	212	210	212	217	219	225	228	211.	24
11	225	225	227	226	222	213	208	206	209	216	224	229	229	217	212	214	214	216	208	201	212	221	219	203	216.	24
12	228	237	233	234	236%	235%	233%	235	237	237	235	233	227	222	208	209	204	209	210	211	214	219	219	221	224.	24
13	224	226	227	228	227	225	225	229	233	233	225	221	216	216	208	215	208	217	217	220	226	231	225	221	223.	24
14	219	218	219	219	218	217	217	217	222	228	225	219	210	207	208	209	205	201	212	219	222	226	230	230	217.	24
15	230	228	226	225	224	225	226	229	233	238	235%	228	217	213	208	222	208	207	220	221	223	222	218	220	223.	24
16	221	223	222	224	223	221	223	227	233	236	231	226	221	218	204	204	203	206	211	218	219	218	207	205	219.	24
17	207	208	209	208	207	208	210	213	215	217	221	220	217	212	210	214	214	213	213	205	202	207	209	213	211.	24
18	214	216	218	215	212	211	213	218	226	233	235	234	235	233	229	236	231	227	227	227	230	229	227	229	225.	24
19	228	229	228	228	227	224%	223	226	227	228	229	228	225	214	209	200	185	186	187	207%	228	225	226	223	218.	24
20	220	223	227	230	230	227	225	225	226	226	226	228	226	224	227	208	211	210	205	206	217	238	231	231	223.	24
21	232	232	216	172	157	150	151	157	159	151	150	140	158	172	175	180	165	156	149	144	141	146	151	156	165.	24
22	160	164	168	170	173	174	176	183	189	193	181	176	165	157	147	135	139	143	145	147	143	146	149	159	162.	24
23	161	159	161	164	165	165	168	174	180	186	191	189	183	162	162	167	162	157	160	167	166	170	173	173	169.	24
24	177	193	197	200	205	209	211	215	218	222	223	220	200	196	192	191	181	180	183	192	193	188	187	190	199.	24
25	189	191	196	196	196	199	196	198	202	203	198	181	169	170	185	196	202	197	192	203	212	214	213	215	198.	24
26	216	217	215	217	216	217	218	219	221	219	213	207	204	207	205	199	211%	211	214	206	207	207	200	206%	211.	24
27	215	214	210	210	211	213	214	216	215	214	218	216	213	212	215	211	213	214	191	192	202	204	202	208	210.	24
28	208	205	201	206	207	205	208	215	218	217	217	212	207	203	198	197	201	200	200	192	196	200	204	208	205.	24
29	204	199	201	203	203	205	207	212	216	219	220	220	217	212	208	209	220	224	227	225%	227%	225%	223%	221%	214.	24
30	221%	217%	211	208%	205%	200%	197%	199%	206%	212	191	180	178	175	173	172	171	168	167	164	157	153	152	149	184.	24
31	149	148	149	154	162	166%	169%	170%	172%	173%	174%	174	177	180	177%	175%	170	170	169	171	173	176	177	175	169.	24
AV	204	205	205	204	204	203	203	206	209	211	210	206	203	201	198	199	197	197	197	199	202	203	203	203	203.	
HR	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31		744

FLAGS:
% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS
# - BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS
$ - ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH)   YEAR 1981   MONTH 8

TEMPERATURE .1 DEG.C

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVG	HR
1	191	187	187	188	181	180	181	183	185	188	192	196	200	203	204	204	204	202	201	194	188	189	189	187	192.	24
2	185	182	181	181	192	182	184	187	193	204$	215	227	240	242	254	263	264	260	255	249	245	239	235	229	220.	24
3	227	225	219	214	212	211	209	216	226	242	262	279	292	303	309	313	315	312	305	298	291	288	276	262	263.	24
4	253	241	237	231	229	228	226	235	254	276	296	308	311	314	326	331	324	321	319	299	288	280	277	275	278.	24
5	272	261	259	252	245	241	240	250	267	288	310	318	320	323	331	337	339	336	317	294	294	289	281	272	289.	24
6	265	258	253	249	243	237	235	240	250	274	287	299	310	307	299	262	266	294	290	282	260	229	217	221	264.	24
7	220	224	226	227	227	228	231	235	245	261	281	300	312	314	262	251	261	263	260	253	250	241	237	232	252.	24
8	228	225	226	226	227	228	230	235	241	241	249	259	265	255	259	260	273	279	276	273	265	255	245	239	248.	24
9	236	231	229	228	226	223	227$	230	242	260	277	296	305	304	309	315	309	297	289	281	276	266	260	250	265.	24
10	247	247	244	243	240	238	235	235	246	249	265	278	291	304	301	291	232	224	234	229	•232	231	227	226	250.	24
11	226	224	227	221	220	218	221	230	245	256	267	283	295	273	264	248	241	252	241	231	226	225	221	218	240.	24
12	216	213	211	211	211	211	212	218	228	245	261	279	288	299	303	307	309	306	299	288	280	267	259	255	257.	24
13	251	237	225	217	214	214	211	215	232	252	272	286	296	302	302	303	302	298	290	284	279	275	269	261	262.	24
14	252	240	239	233	239	227	223	233	255	270	286	293	300	306	300	310	313	309	303	294	288	277	275	273	272.	24
15	267	246	245	243	236	230	234	241	256	276	288	300	311	302	274	244	284	295	291	285	284	277	271	269	269.	24
16	261	254	250	246	243	239	238	247	258	274	289	297	310	319	295#	277#	276#	268	261	253$	245	236	233	236	264.$	21
17	227	222	219	220	221	223	225	231	239	248	254	262	263	265	264	263	254	243	233	223	216	214	213	213	236.	24
18	209	206	205	202	201	199	199	198	198	196	195	189	193	199	201	206	208	208	204	201	199	199	197	201	201.	24
19	200	198	196	195	193	193	194	194	202	217	227	239	238	237	243	249	252	248	245	240	232	225	218	213	220.	24
20	209	206	204	201	201	199	200$	201	204	211	223	237	250	259	258	257	256	254	254	250	244	243	245	239	229.	24
21	233	223	205	203	197	187	187	188	193	201	211	223	223	222	223	223	224	222	215	211	208	203	201	198	[illegible]	24
22	194	190	186	182	179	177	174	183	202	221	234	247	252	265	273	276	276	269	263	257	252	248	235	235	228.	24
23	232	233	229	218	210	205	202	209	225	233	242	247	256	257	259	259	258	258	250	240	230	225	216	208	233.	24
24	200	194	191	189	187	185	185	196	215	239	261	273	283	292	297	272	268	273	276	270	256	249	243	237	239.	24
25	232	225	219	217	215	209	206	217	237	254	272	287	298	306	309	303	299	296	289	281	274	265	258	256	259.	24
26	260	253	241	233	227	224	216	219	225	234	252$	269	280	283	284	286	284	275	267	259	252	248	240	232	252.	24
27	223	217	211	208	207	195	197	207	216	237	251	262	272	276	276	281	277	271	263	257	254	249	241	232	241.	24
28	228	224	217	211	201	188	185	193	208	236	255	267	276	282	285	287	288	284	279	272	267	261	255	251	246.	24
29	245	238	231	226	219	215	216	220	229	236	243	249	257	263	270	274	275	273	268	260	255	252	249	247	246.	24
30	242	239	234	228	225	223	217	214	216	223	239	251	263	252	271	285	284	278	278	271	265	261	252	240	248.	24
31	234	230	225	217	213	209	209	218	227	240	258	269	276	279	291	299	291	287	282	277	274	268	266	261	254.	24
AV	231	226	222	218	215	212	211	217	228	241	255	267	275	278	277$	275$	274$	273	268	260	254	247	242	238	246.$	
HR	31	31	31	31	31	31	31	31	31	31	31	31	31	31	30	30	30	31	31	31	31	31	31	31	741	

FLAGS:

X - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS
- BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS
$ - ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH) YEAR 1981 MONTH 7

TEMPERATURE .1 DEG.C

D A Y													HOUR													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVG	HR
1	233	220	215	217	216	213	212	215	230	245	254	261	258	270	263	249	246	241	230	222	217	209	203	198	231.	24
2	193	191	189	190	191	188	183	184	188	194	199	206	210	215	222	227	232	235	230	205	214	213	209	206	205.	24
3	203	201	200	201	202	203	204	206	213	223	238	246	252	258	240$	221	232	238	239	230	233	229	221	216	223.	24
4	212	210	206	203	201	200	200	205	214	224	237	255	263	276	279	282	284	282	279	275	269	265	260	251	243.	24
5	243	234	229	227	228	229	233	238	245	254	270	280	259	280	222	235	252	250	245	241	238	240	235	231	243.	24
6	225	217	213	212	212	212	215	223	235	245	259	272	263	268	253	245	232	232	235	233	233	226	222	219	233.	24
7	216	212	212	210	207	207	211	221	238	259	279	291	301	303	308	309	314	309	302	294	287	281	272	265	263.	24
8	261	255	252	250	246	243	245	260	280	297	305	313	321	326	331	333	335	330	324	314	304	295	284	278	291.	24
9	274	272	264	260	254	250	255	264	278	296	314	322	333	336	346	344	345	331	323	317	309	298	291	283	298.	24
10	273	268	264	255	248	246	247	261	279	299	318	335	344	348	346	344	342	340	335	326	316	309	298	289	301.	24
11	279	273	266	261	252	246	246	254	267	287	308	321	332	338	343	342	339	335	321	300	293	288	286	270	294.	24
12	267	259	254	248	245	244	242	249	261	282	299	310	321	330	334	334	333	328	321	317	309	304	296	290	291.	24
13	282	276	271	265	261	257	259	264	281	301	313	317	327	330	332	332	332	328	324	316	304	294	288	280	297.	24
14	272	266	259	255	252	248	249	254	272	293	306	314	324	328	334	339	339	336	331	322	313	303	294	288	296.	24
15	280	277	273	269	264	258	260	269	285	304	314	323	330	341	336	310	317	313	299	295	289	282	275	270	293.	24
16	262	257	253	247	244	243	247	259	281	300	312	320	327	338	347	350	348	344	336	324	312	302	290	286	297.	24
17	277	269	261	254	249	244	244	256	272	289	301	312	318	326	331	336	334	334	323	275	253	260	261	252	285.	24
18	244	241	235	231	226	225	229	240	260	275	275	279	290	300	305	301	303	303	298	290	281	274	270	264	268.	24
19	260	256	252	250	241	235	235	246	262	277	292	305	316	326	337	344	344	344	337	323	310	305	296	290	291.	24
20	282	275	269	266	263	258	252	257	273	290	306	317	323	326	332	342	343	343	338	328	316	299	280	269	298.	24
21	263	256	261	258	244	235	235	238	257	276	295	306	313	318	323	329	332	330	322	313	299	287	275	268	285.	24
22	262	255	247	239	237	232	231	244	259	277	293	300	310	322	326	327	324	320	313	303	292	280	268	259	28[illegible]	24
23	248	240	233	230	227	222	225	235	253	269	288	302	316	330	338	338	339	339	332	324	315	306	298	292	285.	24
24	281	273	266	256	244	236	234	243	259	278	291	316	334	346	341	347	352	349	346	338	330	291	259	253	294.	24
25	256	255	243	241	242	235	231	235	246	272	291	311	304	298	305	310	320	328	324	311	300	291	289	280	280.	24
26	268	268	267	257	256	247	244	256	276	297	315	325	333	339	346	343	281%	277	274	265	256	245	256	256	281.	24
27	240	237	236	238	233	227	233	253	261	271	292	312	319	322	327	335	329	308	308	299	287	270	275	269	279.	24
28	268	268	268	265	260	257	257	265	280	301	317	327	332	339	345	345	342	337	328	318	311	306	300	288	301.	24
29	281	274	262	255	247	245	246	260	270	277	283	292	307	315	304	268	248	239	240	237	236	233	230	230	262.	24
30	231	228	223	217	211	207	206	208	214	230	216	227	236	232	232	233	235	233	232	224	215	203	195	190	220.	24
31	188	188	186	185	181	177	176	177	178	181	182	186	189	191	187	187	187	186	187	189	190	192	194	195	186.	24
AV	252	247	243	239	235	231	232	240	254	270	283	294	300	307	307	306	304	301	298	286	278	270	264	257	271.	
HR	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31		744

FLAGS:

% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS
# - BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS
$ - ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

```
                    ATLANTA (GA TECH)      YEAR 1981     MONTH  8

                                  WIND DIRECTION DEG.

 D                                                  HOUR
 A   1    2    3    4    5    6    7    8    9   10   11   12   13   14   15   16   17   18   19   20   21   22   23   24    AVG  HR
 Y  --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   --   ----  --

 1  66   55   52   54   49   57   56   55   54   56   55   40   62   55   54   53   43   40   56   56   50   77   44   49    54. 24
 2  54   49   60   63   44   52   65   48   67   54$  40   53   44  136   64   72   55   77   89  107   97  103  116  109    71. 24
 3 109  110   78   88   91   84  103  130  152  183  177  221  247  233  217  218  245  232  234  246  200  154  166  182   183. 24
 4 207  207  204  218  198  225  285  208  277  251  224  291% 307   47% 152  165   99  130  127%  38   30   30   64  111   180. 24
 5 174  183  189  216  218  215  213  253  300  326  232  222  194  177  168  189  202  188  137  208  194  202  218  213   199. 24
 6 211  210  207  211  214  229  218  225  227  241  241  232  243  228  212  251  191  212  223  287   57    6  203  266   227. 24
 7 249  209  242  198  212  224  229  233  247  273  266  261  267  298  246  254  214  202  236  347  209  216  194  199   233. 24
 8 216  235  222  235  243  244  244  228  268  267  257  242  222  265  192  184  205  217  192  186  187  197  213  208   226. 24
 9 224  222  219  246  264  233  240$ 247  280  339  354    9  345  324  313  346  108  106  114  130  129  178  226  216   213. 24
10 210  223  339  124  345  143  186  201  191  185  192  166  167  149  139  168  281  271  180  326  121  115  118   96   180. 24
11 134  150  158  183  210  223  218  228  229  272  315  345   24  294  300  330  226  213  177  139  150  190  258  204   220. 24
12 240  238  308  282  271  307  311  305  293  314  313  333  301  309  308  322  323  351    7   25  141  197  206  200   303. 24
13 196   78  109  130  196  304  336   39   17  356   36   28   26   15   54   45   67   91  115  111  135  149  159  217    74. 24
14 338%   0   56   56   93   28   41   62  356  270   58    6   72   31  342  350  353  352  174% 168  183  181  164  161    42. 24
15 171  206  201  215  238  225  166  223  245  247  221  235  208  264% 349  222  148  160  152  164  166  180  184  201   207. 24
16 211  215  216  220  229  235  230  228  286  306  311  281  288  339  182* 197* 164* 176  231  259$ 287  242  185  182   241.$21
17 221  277  332  358    0  216  200  265  342    1   31   45   38   29   45   53   56   61   57   61   61   65   71   74    50. 24
18  66   69   68   70   65   66   64   62   69   66   74   79   79   75   76   79   65   66   79   86   78   78   76   75    72. 24
19  84   66   64   57   58   51   39   42   38   44   62   55   36   27   44   34   14    7   57   63   62   53   57   57    51. 24
20  76   65   79  101  108  117   96$  74   76   86   80   78  118  127  105   99  104   73   59  344  252  227  111  123    93. 24
21 [illegible] 119  135  109   61   46   50   60   61   79   83   84   70   73   75   93  101  101  123  124  122  135  134  111    91. 24
22  82   79   70   60   53   58   55   47   68   70   66   68   46   67   66   56   65  118  140  153  147  148  299  191    75. 24
23 188  165  168  216   50   34   53   48   50   50  105   92  123  125  149  138  142  130  136  161  170  168  178  199   144. 24
24 214  210  218  237  295  309  347  342  325  324  341  353  343  332  327   14  228  225  232  247  243  256  266  277   300. 24
25 292  284  289  302  320  346  351   21   49  338    3  338  345  316  340  326  334  350  348  345  343  339    6   75   342. 24
26 116  124  125  105  112  117   70   61   64   78   96$ 114  117  121  121  106  114  108  109  102  103  110  120  107   106. 24
27 116  123  123  120  115   62   99  107  107  108  115  118  118  126   97  120  120  129  133  129  120  113  113  106   116. 24
28 115  118  105  107   77   49   54   57   60   72   88   77   86   87  102   72   70  109  114  110  100   82   81   76    88. 24
29  84   86   65   62   47   61   71   74   76   68   72   77   83   77   82   76  102  118  115  115  124  104  104  107    88. 24
30  92  106   97   84   68   59   51   88   62   75  111   71   79   59   94  121   65   57   77  108  124  119   96   94    85. 24
31 106  105   88   76   72   57   82   93  114  122  110  131  101   94  108  140  153  141  162  177  171  180  173  158   120. 24
-- ---  ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- ---- -----
AV 137  128  121  110   93   64   67   71   53   49   70   69   71   61   82$  82$  92$ 112  124  117  124  130  135  134   102.8

HR  31   31   31   31   31   31   31   31   31   31   31   31   31   31   30   30   30   31   31   31   31   31   31   31         741

----------
FLAGS:
% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS
* - BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS
$ - ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
    OR BY SUMMATIONS HAVING UNAVAILABLE HOURS
```

ATLANTA (GA TECH)   YEAR 1981   MONTH 7

WIND DIRECTION DEG.

HOUR

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVG	HR
1	50	64	74	90	179	214	259%	87	105	129	127	100	74	93	90	76	79	99	123	89	88	110	117	114	95.	24
2	118	104	99	105	124	180	173	121	139	120	95	102	92	105	115	137	145	185	196	129	128	117	101	86	126.	24
3	77	84	81	88	90	81	68	84	93	102	98	86	53	38	63$	87	75	76	87	89	101	109	94	108	85.	24
4	105	102	75	76	96	91	85	71	159	191	225	231	231	208	215	196	214	216	205	191	180	168	167	176	174.	24
5	196	200	199	198	222	221	201	200	199	212	217	211	216	240	202	202	209	216	234	218	196	193	207	206	210.	24
6	233	221	217	209	207	213	232	228	222	230	240	231	211	219	260%	203	201	259	225	184	201	219	219	230	221.	24
7	245	227	228	248	265	288	290	302	281	263	281	301	305	318%	316	307	304	293	306	310	350	319%	259	263	287.	24
8	272	280	299	315	327	340	310	341	328	338%	337%	319%	335%	334%	337%	320%	325	327%	332	335	329	332	346	359	328.	24
9	3	10	336%	32	355	26	25	15	16	26	15	8	32	328	355%	333	335%	299	324	325	347	323	339	313	347.	24
10	293	305	326	304	285	292	312	322	331	344#	14#	328#	347	349	315	330	302	301	299	284	274	279	270	288	305.$	21
11	346	316	258	274	244	311	325	309	314	321	231	244	237	229	229	222	227	229	341%	40	335	315	354	88	275.	24
12	72	213	65	95	27	346	337	335	352	334	299	281	261	254	280	302	302	301	292	268	255	235	239	243	288.	24
13	249	254	260	266	267	266	286	275	297	311	318	326	333	306	300	296	297	307	305	307	288	288	293	263	299.	24
14	263	271	279	286	283	274	280	290	296	316	328	317	316	310	307	292	282	298	269	267	236	250	265	272	289.	24
15	277	274	292	280	287	286	292	296	311	319	321	327	315	283	275	279	278	307	329	348	335	337	338	262	301.	24
16	253	246	260	276	266	276	293	295	290	300	304	303	288	271	265	270	275	278	271	266	249	330	348	296	283.	24
17	256	259	287	323	304	287	277	319	332	309	324	313	300	308	283	273	310	299	306	320	32	54	334	297	311.	24
18	358	13	355	338	350	356	5	1	32	64	61	67	66	57	66	59	59	55	61	59	56	74	86	86	52.	24
19	106	105	96	84	67	62	72	95	111	104	125	177	202	280	230	298	344	327	327	317	196	118	184	190	100.	24
20	179	215	213	211	191	197	223	246	265	302	291	298	299	296	225	296	271	263	272	245	219	202	205	212	249.	24
21	222	243	288	297	278	228	225	250	301	310	308	311	297	307	308	298	291	282	287	301	309	303	303	333	285.	24
22	339	317	318	341	301	258	218	333	344	330	308	319	324	318	318	317	313	311	318	334	340	350	347	344	324.	24
23	346	355	355%	23	6%	357	22	46	67	68	57	71	39	115	323	3	332	346	352	80	31	357	18	28	27.	24
24	66	95	104	77	62	60	61	63	73	70	65	125	216	197	43	276	198	238	223	245	279	322	333	336	47.	24
25	8	105	330	55	24	282	288	336	335	319	327	298	300	305	317	316	225	302	318	241	207	229	299	293	306.	24
26	233	204	199	243	196	287	292	353	353	259	217	220	217	265	259	314	225	174	164	94	81	23	113	216%	210.	24
27	243	44	95	113	358	3%	348	271	287	276	282	300	308	268	239	249	244	231	244	226	221	222	243	236	257.	24
28	222	219	191	114	186	194	211	237	260	282	269	268	256	247	237	243	236	222	235	272	261	221	212	214	241.	24
29	216	226	235	227	240	252	257	280	291	313	281	283	262	286	310	317	231	242	214	251	256	270	295	303	266.	24
30	307	314	278	271	284	309	331	351	351	24	59	67	75	73	57	62	56	79	80	76	77	60	63	64	53.	24
31	64	67	58	62	70	50	39	52	51	52	51	58	62	62	62	51	45	41	28	36	50	59	79	69	58.	24
AV	250	227	307	313	281	269	283	315	318	321$	316$	309$	303	298	294	298	275	276	284	302	298	300	281	248	295.$	
HR	31	31	31	31	31	31	31	31	31	30	30	30	31	31	31	31	31	31	31	31	31	31	31	31		741

FLAGS:

% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS

- BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS

$ - ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH)   YEAR 1981   MONTH 8

WIND SPEED .1 M/S

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVG	HR
1	39	41	33	38	38	42	32	41	37	31	27	25	23	35	37	30	38	35	35	35	35	36	23	30	34.	24
2	32	23	23	23	17	23	18	21	23	21$	19	13	10	16	20	23	25	30	12	15	22	15	29	29	21.	24
3	25	20	14	23	12	20	18	13	16	11	15	19	20	26	37	37	29	25	23	18	12	24	40	43	23.	24
4	28	26	33	23	23	12	3	8	11	13	12	15	15	17	28	21	18	21	8	19	21	16	19	19	18.	24
5	27	43	30	28	21	20	22	19	12	18	15	22	32	32	37	32	35	43	36	39	37	43	36	39	30.	24
6	43	43	40	42	44	34	39	41	46	47	46	44	49	52	68	43	33	47	52	33	31	59	31	15	43.	24
7	12	26	12	25	33	37	36	33	39	36	35	45	28	27	54	16	27	35	24	7	25	30	36	45	30.	24
8	43	35	26	31	38	30	27	30	36	32	26	10	20	14	18	20	12	10	22	26	29	23	30	25	26.	24
9	20	23	26	23	18	11	12$	13	5	3	6	18	23	31	31	28	23	29	40	34	35	26	16	21	21.	24
10	15	13	3	2	1	5	26	24	18	27	25	23	20	28	32	45	55	27	10	11	17	18	24	16	20.	24
11	16	7	20	14	7	8	10	11	18	22	10	11	14	35	31	54	20	26	27	45	37	27	13	19	21.	24
12	13	11	17	22	26	22	21	19	33	18	25	21	27	28	27	29	38	36	27	22	25	32	19	15	24.	24
13	23	32	38	22	10	7	17	7	13	12	19	26	28	29	30	25	28	20	26	22	23	19	8	1	20.	24
14	2	11	8	13	9	14	17	16	4	5	16	13	18	14	27	16	16	10	10	14	20	10	9	17	13.	24
15	25	6	12	10	9	4	7	17	16	31	45	39	30	26	47	41	22	16	24	20	25	32	31	33	24.	24
16	47	47	41	37	34	32	29	29	28	38	39	23	18	23	34#	38#	44#	35	32	26$	20	21	19	15	31.$	21
17	25	11	12	10	12	13	11	5	11	27	38	38	41	43	45	48	53	53	50	60	63	61	56	51	35.	24
18	49	45	55	53	50	57	60	63	64	71	63	65	54	73	50	53	50	56	53	49	42	57	47	44	55.	24
19	48	58	52	54	53	48	35	26	33	47	52	45	39	37	28	34	38	35	32	37	43	45	44	33	41.	24
20	30	23	32	24	24	23	25$	27	35	40	40	31	26	29	22	23	18	12	8	13	12	9	26	33	24.	24
21	[illegible]	55	52	47	44	46	49	52	55	52	51	61	55	49	46	39	40	34	32	32	33	40	31	24	44.	24
22	28	34	35	33	34	33	26	25	33	30	34	27	23	24	28	25	18	24	19	19	22	17	11	11	25.	24
23	19	18	14	7	5	14	12	8	15	13	15	18	12	18	18	23	24	24	33	36	33	36	38	29	20.	24
24	20	20	19	6	11	9	19	18	26	23	33	37	27	30	27	38	18	13	9	16	30	27	29	18	22.	24
25	15	14	10	7	13	17	19	16	16	9	19	20	22	25	27	37	40	36	27	25	14	19	15	15	20.	24
26	31	47	47	44	45	42	32	40	47	46	46$	45	44	45	46	41	40	44	46	31	28	35	37	32	41.	24
27	30	49	44	41	36	24	22	28	33	35	45	46	47	48	42	37	39	47	40	27	29	32	40	29	37.	24
28	25	27	21	22	17	20	16	19	24	34	37	42	35	31	32	23	27	40	30	26	26	29	38	37	28.	24
29	32	27	24	23	20	24	22	28	29	32	36	35	31	29	31	32	40	41	42	29	34	24	30	29	30.	24
30	31	34	34	33	26	22	27	29	29	30	23	23	16	33	18	18	30	29	23	22	25	18	27	29	26.	24
31	39	38	22	34	24	24	31	31	28	25	19	24	20	22	29	34	38	33	31	29	22	24	22	9	27.	24
AV	28	29	27	26	24	24	24	25	27	28	30	30	28	31	34$	32$	31$	31	28	27	28	29	28	26	28.8	
HR	31	31	31	31	31	31	31	31	31	31	31	31	31	31	30	30	30	31	31	31	31	31	31	31		741

FLAGS:
% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS
# - BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS
$ - ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

ATLANTA (GA TECH)   YEAR 1981   MONTH 7

WIND SPEED .1 M/S

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AVG	HR
1	34	40	25	13	9	13	18	25	24	28	29	28	42	41	48	53	44	39	31	35	25	37	43	49	32.	24
2	43	29	35	31	34	45	41	29	29	26	30	29	31	32	30	33	29	43	38	27	33	29	48	43	34.	24
3	40	38	40	42	39	34	29	36	34	37	26	18	16	17	20$	23	25	21	25	26	21	22	24	34	29.	24
4	36	32	27	26	15	12	11	10	10	13	18	20	22	20	27	32	39	39	32	29	30	31	40	37	25.	24
5	28	33	33	45	45	34	27	39	40	43	58	63	46	52	75	67	65	61	49	33	24	38	49	42	45.	24
6	48	36	36	36	48	40	37	29	41	49	43	37	47	24	26	28%	35	17	40	31	32	36	29	32	35.	24
7	22	25	25	25	23	24	24	27	29	37	47	40	37	41	31	28	29	29	29	17	10	15	12	21	27.	24
8	26	20	24	17	19	12	7	22	29	42	42	44	40	43	39	42	41	40	30	29	30	29	29	29	30.	24
9	32	19	14	13	17	10	14	16	19	18	16	24	23	28	30	32	37	44	37	34	28	22	14	15	23.	24
10	9	12	12	10	6	8	7	12	13	0*	0*	14*	26	27	26	34	35	34	29	28	30	26	20	24	21.$	21
11	16	19	13	11	30	30	29	24	21	13	11	23	35	42	41	39	39	32	29	25	26	19	12	46	26.	24
12	21	20	28	23	11	5	19	12	10	22	34	34	33	34	47	40	40	34	31	26	22	22	24	23	26.	24
13	24	18	18	13	18	18	18	23	27	43	58	63	51	49	65	65	59	50	44	38	29	29	22	15	36.	24
14	25	24	25	43	32	28	34	39	45	50	52	54	48	51	44	49	57	53	40	37	26	37	36	35	40.	24
15	29	26	26	17	32	32	25	23	24	33	41	42	42	33	50	44	29	36	35	16	16	20	13	8	29.	24
16	14	14	23	21	16	20	34	34	38	52	55	47	39	44	53	56	59	57	51	39	32	38	29	20	37.	24
17	26	22	26	32	26	24	22	31	32	42	40	33	29	35	36	33	38	33	49	77	54	26	17	14	33.	24
18	21	18	13	15	25	23	10	14	14	25	37	37	30	35	38	45	35	37	38	37	34	34	40	41	29.	24
19	37	31	9	13	25	24	26	21	22	15	18	14	24	19	18	22	27	18	21	16	12	25	18	9	20.	24
20	20	23	21	22	16	22	32	29	26	39	43	37	43	49	42	49	47	48	46	34	31	49	53	52	36.	24
21	49	49	43	45	44	33	36	44	34	52	43	55	61	63	67	56	64	64	60	50	35	27	24	24	[illegible]	[illegible]
22	22	22	24	25	18	3	5	16	23	29	46	50	48	33	43	56	54	54	54	40	29	28	31	36	33.	24
23	22	28	33	18	22	19	28	35	50	40	29	29	19	20	21	24	23	24	24	20	16	8	15	20	25.	24
24	25	37	45	27	27	27	29	34	24	20	22	11	18	18	23	10	27	21	18	8	14	78	58	21	27.	24
25	10	20	25	18	15	21	22	25	21	24	26	40	49	42	34	22	16	23	26	22	23	20	11	16	24.	24
26	14	18	5	9	9	13	7	9	6	9	21	29	31	26	28	35	83	53	49	38	42	33	22	19	25.	24
27	23	11	14	8	7	11	4	16	25	26	23	32	33	35	25	38	34	43	36	27	23	23	17	15	23.	24
28	11	9	11	6	8	27	27	36	40	43	47	51	45	48	47	55	53	49	39	29	22	24	32	32	33.	24
29	37	44	35	30	32	27	28	32	29	32	30	34	41	41	61	46	41	31	22	29	31	35	32	32	33.	24
30	24	25	21	29	35	20	23	29	15	41	62	63	63	65	63	60	59	47	49	52	60	61	58	67	45.	24
31	57	52	58	56	34	20	24	33	42	45	44	43	50	49	51	48	37	33	24	20	18	21	22	36	38.	24
AV	27	26	25	24	23	22	22	26	27	33$	36$	38$	38	37	40	41	42	39	36	31	28	30	29	29	31.3	
HR	31	31	31	31	31	31	31	31	31	30	30	30	31	31	31	31	31	31	31	31	31	31	31	31		741

FLAGS:

% - QUESTIONABLE HOURLY VALUE, INCLUDED IN SUMS

* - BAD OR UNAVAILABLE VALUE, NOT INCLUDED IN SUMS

$ - ESTIMATED VALUE, BY INTERPOLATION BETWEEN ADJACENT HOURS
OR BY SUMMATIONS HAVING UNAVAILABLE HOURS

Appendix E

Aircraft Flight Maps and Ozone Concentration (ppb)

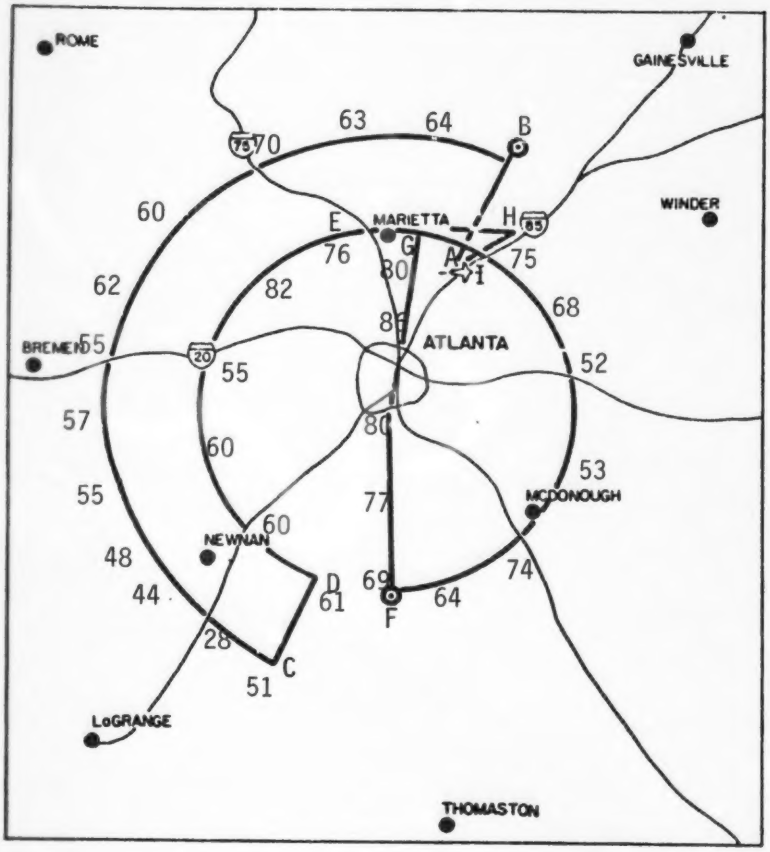


Figure E1. Flight #81-1 on July 13, 1981

TIME: 8:22 to 11:11 PM

Leg AB: 8:22 - 8:49 ascent from 6500' to 2900' AGL
BC: 8:49 - 9:28 at 2900'
CD: 9:28 - 9:32 at 2900'
DE: 9:32 - 9:52 2900' to 1500'
EF: 9:52 - 10:17 at 1500'
FG: 10:17 - 10:46 1500' to 7500' to 2000'
GH: 10:46 - 10:57 at 2000'
HI: 10:57 - 11:11 2000' to 1000' - landing

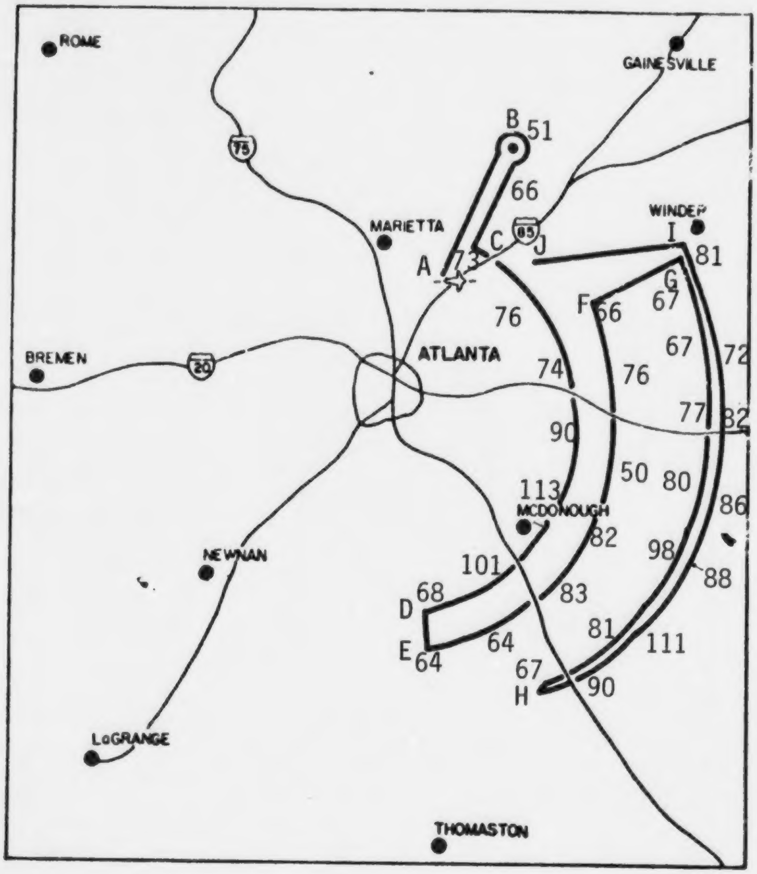


Figure E2. Flight #81-2 on July 13, 1981

TIME: 13:28 to 15:54 PM

Leg AB: 13:28 - 13:40 ascent to 7000' AGL
BC: 13:40 - 13:53 7000' t0 2000'
CD: 13:53 - 14:18 at 2000'
DE: 14:18 - 14:22 2000' to 3500'
EF: 14:22 - 14:44 at 3500'
FG: 14:44 - 14:48 at 3500'
GH: 14:48 - 15:13 3500' to 2000'
HI: 15:13 - 15:43 at 2000'
IJ: 15:43 - 15:54 2000' to landing

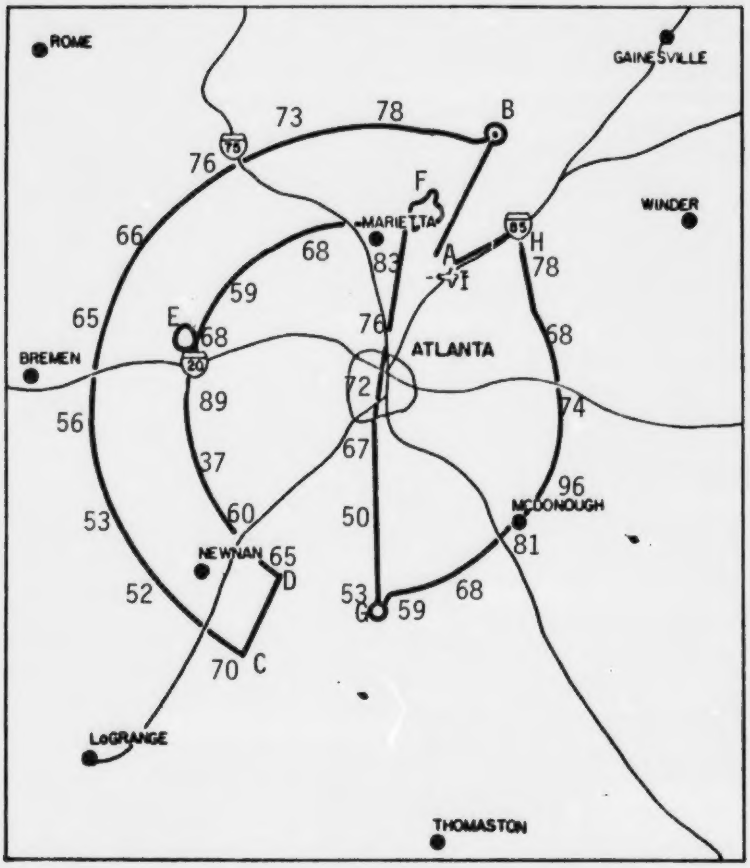


Figure E3. Flight #81-3 on July 14, 1981

TIME: 8:10 to 11:30 AM

Leg AB: 8:10 - 8:48 up to 9000' and down to 2500' AGL
BC: 8:48 - 9:22 at 2500'
CD: 9:22 - 9:27 at 2500'
DE: 9:27 - 9:44 2500' to 1500'
EF: 9:44 - 9:60 1500' to 2000'
FG: 9:60 - 10:58 2000' to 4000' to 10,000' to 1500'
GH: 10:58 - 11:23 1500' to 2000'
HI: 11:23 - 11:30 2000' to 1000' to landing

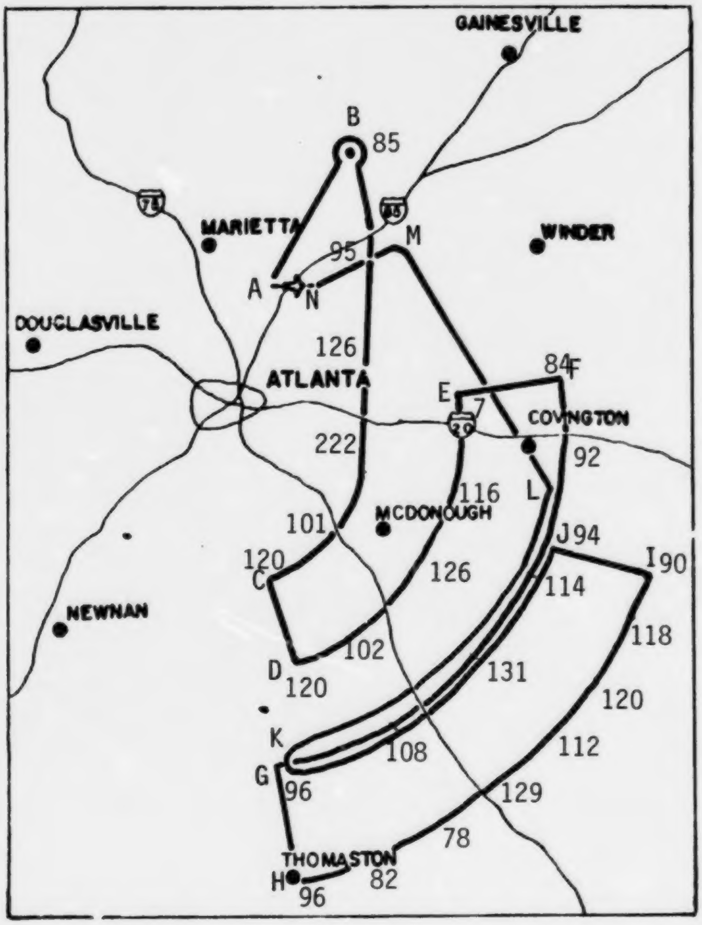


Figure E4. Flight #81-4 on July 14, 1981

TIME: 13:29 to 16:41 PM

Leg AB: 13:29 - 13:58 ascent to 9000'and down to 2000' AGL
BC: 13:58 - 14:19 at 2000'
CD: 14:19 - 14:22 at 2000'
DE: 14:22 - 14:39 at 2000'
EF: 14:39 - 14:46 at 2000'
FG: 14:46 - 15:06 at 2000'
GH: 15:06 - 15:08 2000' to 1500'
HI: 15:08 - 15:35 1500' to 3000'
IJ: 15:35 - 15:42 at 3000'
JK: 15:42 - 16:04 3000' to 4400'

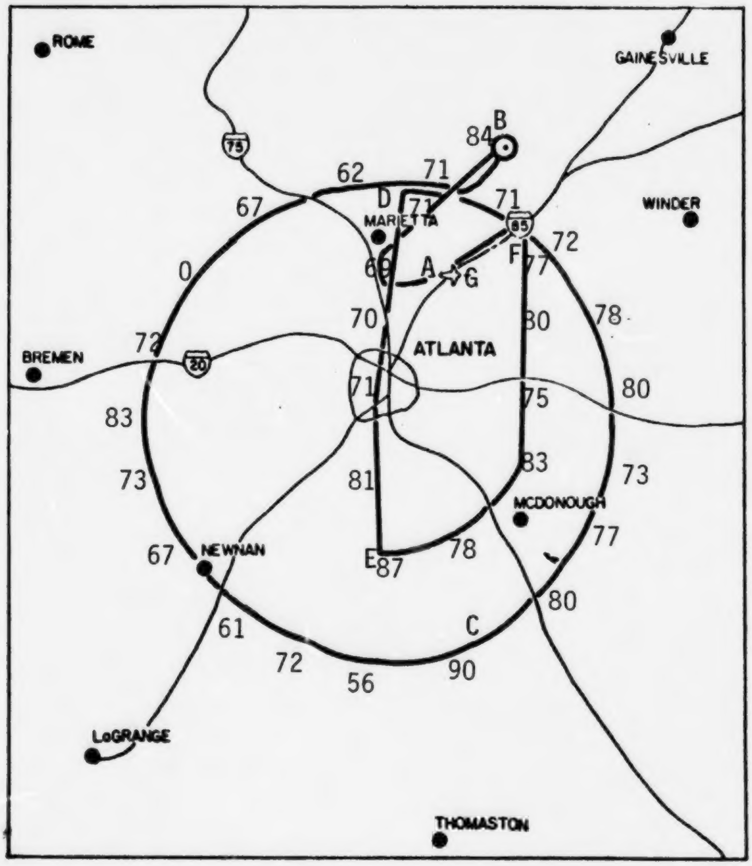


Figure E5. Flight #81-5 on July 15, 1981

TIME: 8:09 to 10:55 AM

Leg AB: 8:09 - 8:46 up to 9000' and down to 2000' AGL
BC: 8:46 - 9:35 2000' to 1000' to 2500' to 1500'
CD: 9:35 - 10:04 1500' to 2500' to 1500' to 2500' to 4000'
DE: 10:04 - 10:20 4000' to 1500'
EF: 10:20 - 10:48 1500' to 2000'
FG: 10:48 - 10:55 2000' to 1000' to landing

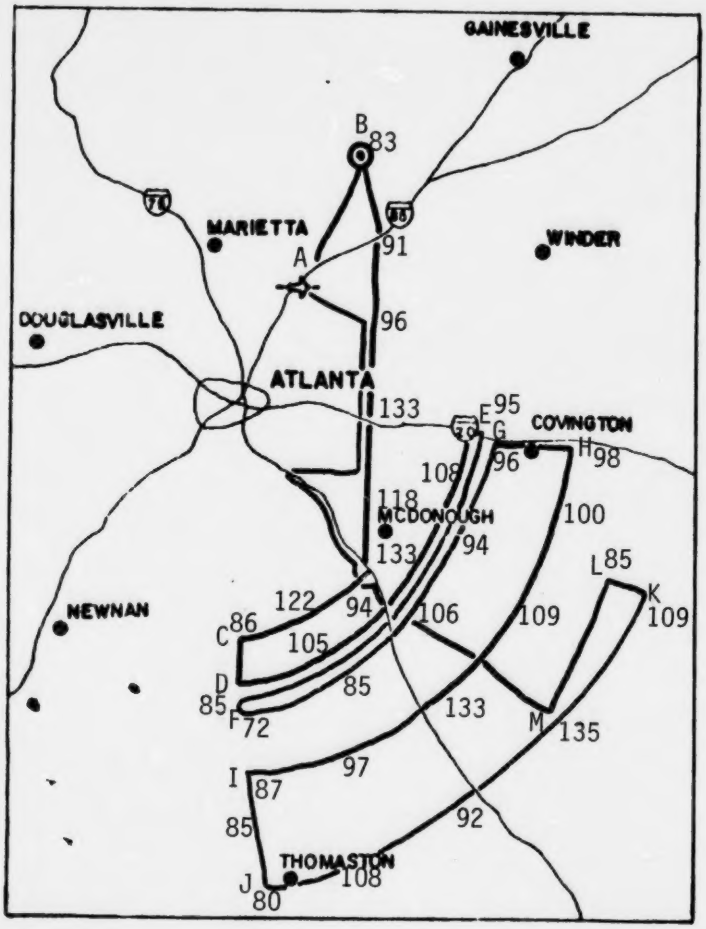


Figure E6. #81-6 on July 15, 1981

TIME: 13:14 to 16:42 PM

Leg AB: 13:14 - 13:44 up to 9000' and down to 1500 AGL
BC: 13:44 - 14:10 at 1500'
CD: 14:10 - 14:12 at 1500'
DE: 14:12 - 14:34 1500' to 2500'
EF: 14:34 - 14:49 at 2500'
FG: 14:49 - 15:08 2500' to 4000'
GH: 15:08 - 15:14 4000' to 1500'
HI: 15:14 - 15:34 at 1500'
IJ: 15:34 - 15:39 1500' to 2000'
JK: 15:39 - 15:57 at 2000'
KL: 15:57 - 16:00 2000' to 3500'
LM: 16:00 - 16:08 3500' to 2000'
MN: 16:08 - 16:26 2000' to 1000'
NO: 16:26 - 16:30 at 1000'
OP: 16:30 - 16:37 1000' to 2000'
PQ: 16:37 - 16:42 2000' down to 500' to landing

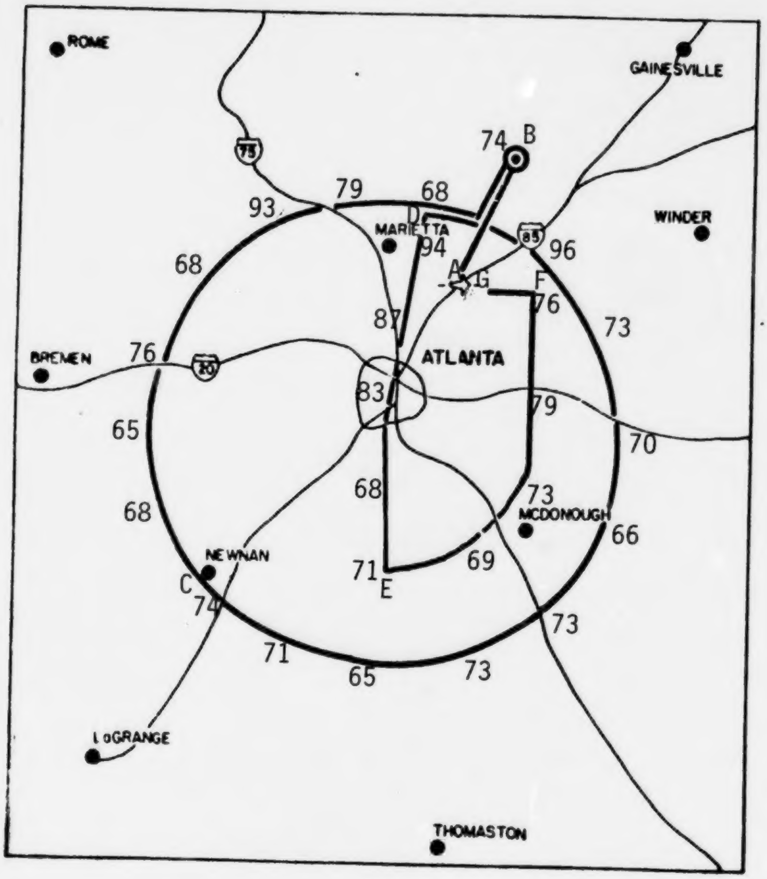


Figure E7. Flight #81-7 on July 16, 1981

TIME: 8:20 to 10:32 AM

Leg AB: 8:20 - 8:48 up to 8000' and down to 1500' to 2000' AGL
BC: 8:48 - 9:18 2000' to 2500'
CD: 9:18 - 9:56 2500' to 3000'
DE: 9:56 - 10:12 3000' to 2500'
EF: 10:12 - 10:26 2500' to 1400'
FG: 10:26 - 10:32 1400' to landing

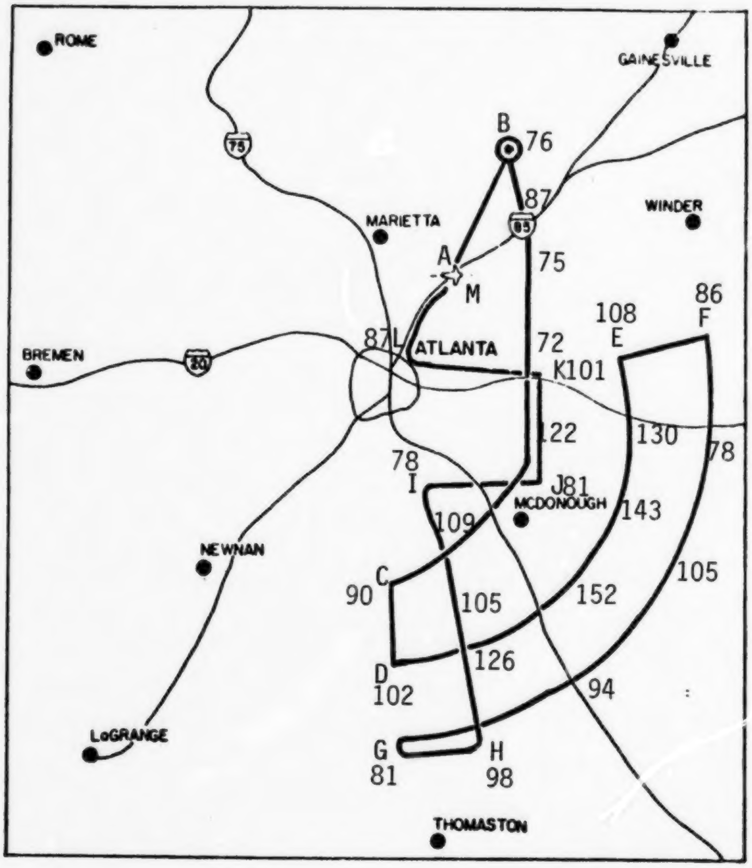


Figure E8. Flight #81-8 on July 16, 1981

TIME: 13:21 to 15:55 PM

Leg AB: 13:21 - 14:07 ascent up to 7000' and down to 2000' AGL
BC: 14:07 - 14:33 at 2000'
CD: 14:33 - 14:37 at 2000'
DE: 14:37 - 15:00 2000' to 500' to 5500' to 2000'
EF: 15:00 - 15:12 at 2000'
FG: 15:12 - 15:23 at 2000'
GH: 15:23 - 15:26 at 2000'
HI: 15:26 - 15:33 at 2000'
IJ: 15:33 - 15:37 2000' to 1500'
JK: 15:37 - 15:46 at 1000'
KL: 15:46 - 15:49 at 1000'
LM: 15:49 - 15:55 1000' to landing

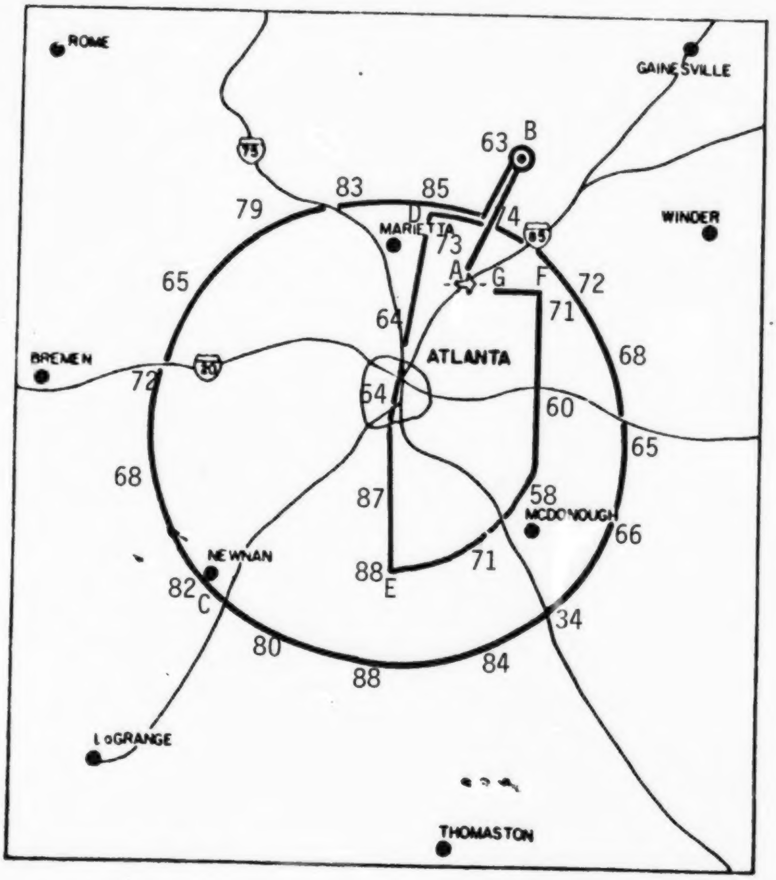


Figure E9. Flight #81-9 on July 17, 1981

TIME: 8:09 to 10:19 AM

Leg			
Leg	AB:	8:09 - 8:30	up to 6000' and down to 500' AGL
	BC:	8:30 - 8:35	500' to 2500'
	CD:	8:35 - 9:02	2500' to 1500'
	DE:	9:02 - 9:41	at 1500'
	EF:	9:41 - 9:57	at 1500'
	FG:	9:57 - 10:13	at 1500'
	GH:	10:13 - 10:19	1500' to 500' to landing

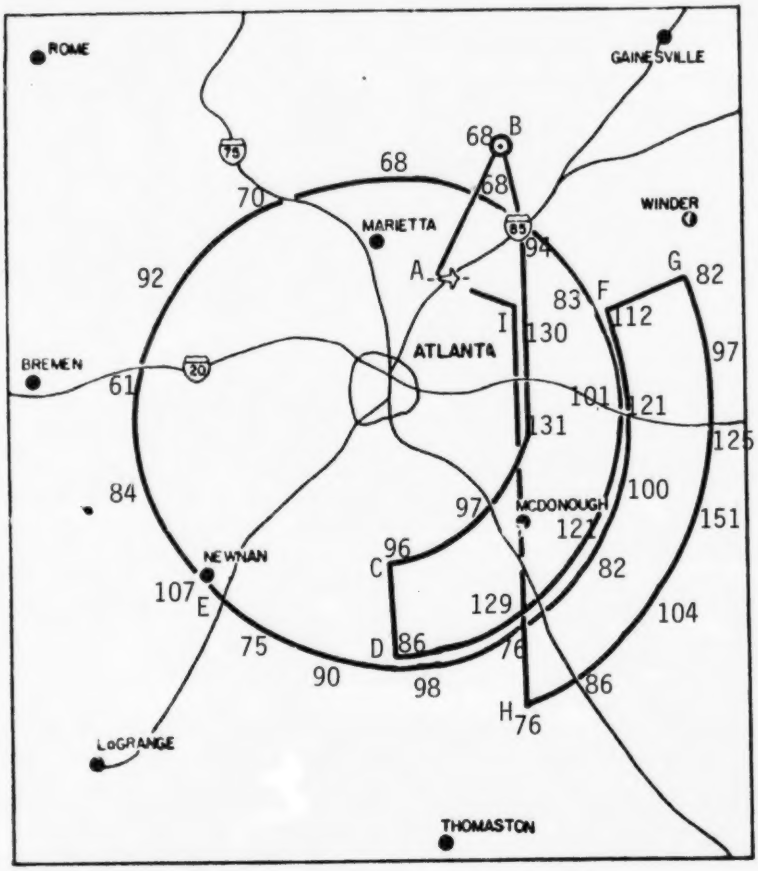


Figure E10. #81-10 on July 17, 1981

TIME: 12:42 to 15:48 PM

Leg AB: 12:42 - 13:08 up to 6500' and down to 2500' AGL
BC: 13:08 - 13:27 2500' to 1500' to 2500'
CD: 13:27 - 13:37 at 2500'
DE: 13:37 - 14:17 at 2500'
EF: 14:17 - 14:56 2500' to 3500'
FG: 14:56 - 15:00 3500' to 2500'
GH: 15:00 - 15:24 at 2500'
HI: 15:24 - 15:42 2500' to 1500;
IJ: 15:42 - 15:48 1500' to landing

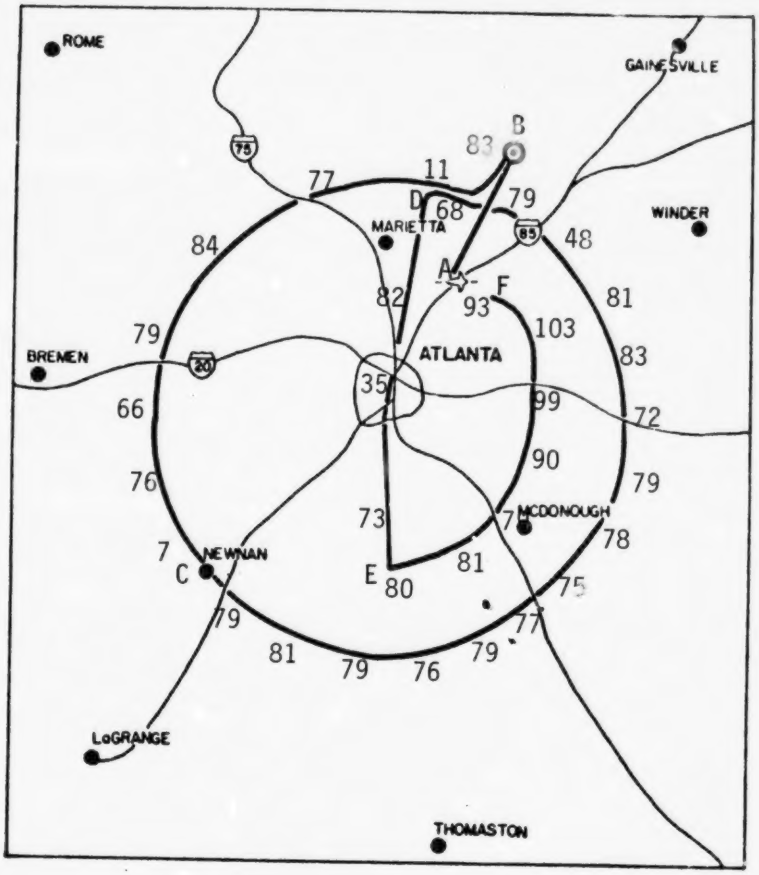


Figure E11. #81-11 on July 20, 1981

TIME: 9:05 to 11:21 AM

Leg AB: 9:05 - 9:13 up to 6000' AGL
BC: 9:13 - 9:35 6000' tp 2000'
CD: 9:35 - 10:45 2000' to 2500' to 1500'
DE: 10:45 - 10:55 1500'
EF: 10:55 - 11:21 1500' to landing

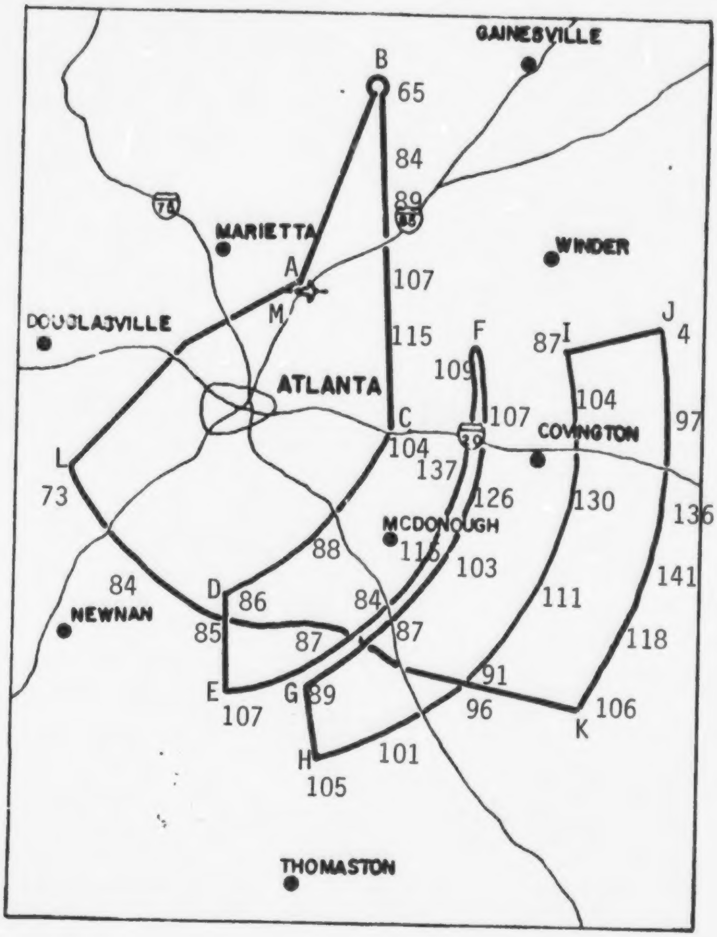


Figure E12. Flight #81-12 on July 20, 1981

TIME: 13:11 to 17:07 PM

Leg AB: 13:11 - 13:29 up to 6500' AGL
BC: 13:29 - 13:49 6500' to 1500'
CD: 13:49 - 13:57 at 1500'
DE: 13:57 - 14:02 at 1500'
EF: 14:02 - 14:21 at 1500'
FG: 14:21 - 14:42 1500' to 2500'
GH: 14:42 - 14:47 2500' to 2000'
HI: 14:47 - 15:09 2000'
IJ: 15:09 - 15:15 2000'
JK: 15:15 - 15:35 2000' to landing

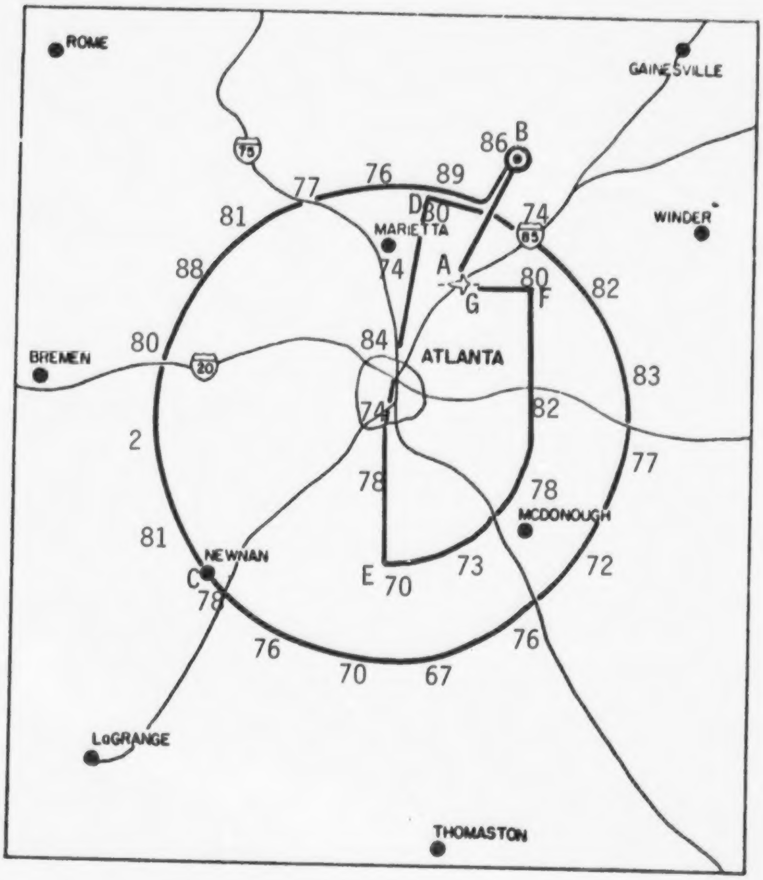


Figure E13. #81-13 on July 23, 1981

TIME: 8:25 to 10:32 AM

Leg AB: 8:25 - 8:41 up to 5500' and down to 2000' AGL
BC: 8:41 - 9:16 2000' to 1000' to 2500' to 1500' 2000' to 1500'
CD: 9:16 - 9:52 at 1500'
DE: 9:52 - 10:12 at 1500'
EF: 10:12 - 10:24 at 1500'
FG: 10:24 - 10:32 1500' to landing

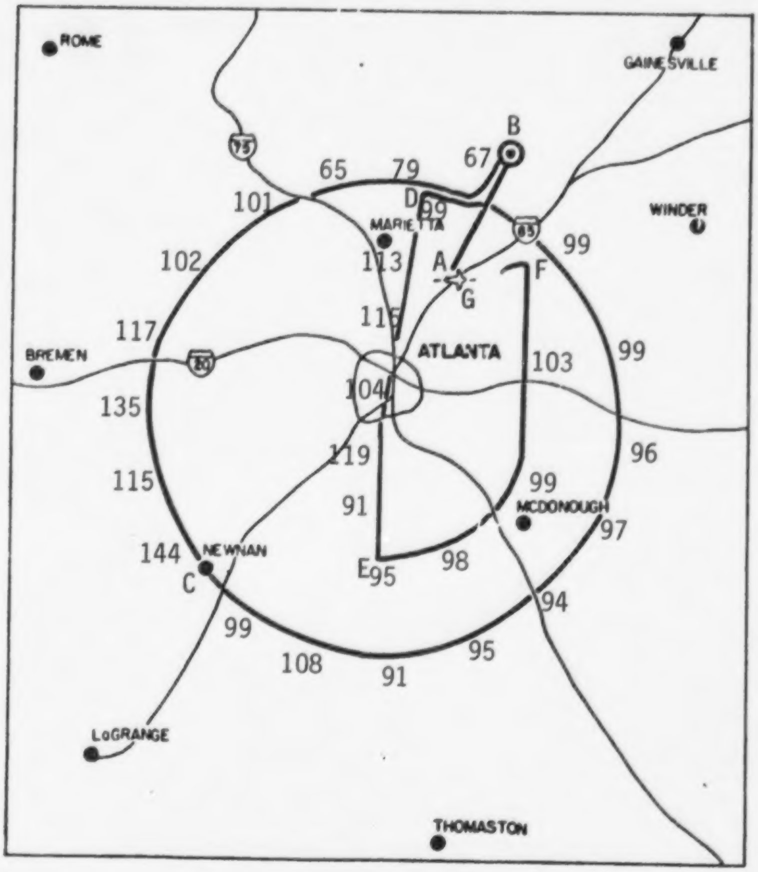


Figure E14. Flight #81-14 on July 24, 1981

TIME: 8:16 to 10:26 AM

Leg AB: 8:16 - 8:26 ascent up to 7000' AGL
BC: 8:26 - 9:27 7000' to 1000' to 2500'
CD: 9:27 - 9:50 at 2500'
DE: 9:50 - 10:18 at 2500'
EF: 10:18 - 10:23 at 2500'
FG: 10:23 - 10:26 2500' to 1500' to landing

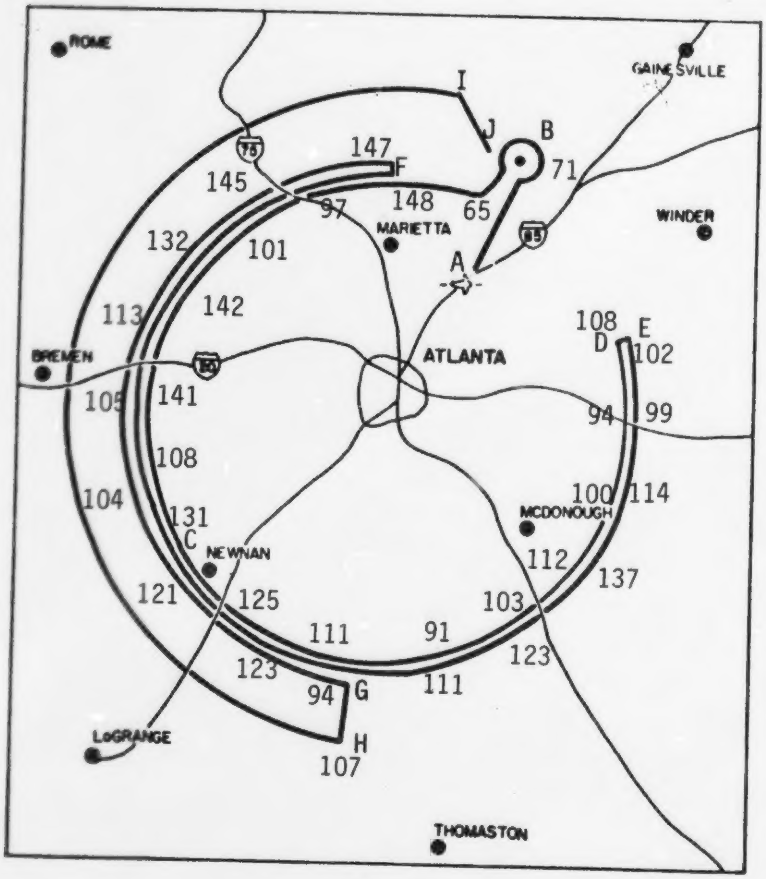


Figure E15. Flight #81-15 on July 24, 1981

TIME: 12:36 to 16:29 PM

Leg AB: 12:36 - 12:46 up to 7000' AGL
BC: 12:46 - 13:26 7000' to 1000' to 2500'
CD: 13:26 - 14:02 2500' to 1500'
DE: 14:02 - 14:03 at 1500'
EF: 14:03 - 15:02 1500' to 3500'
FG: 15:02 - 15:33 at 3500'
GH: 15:33 - 15:37 3500' to 2500'
HI: 15:37 - 16:21 at 2500'
IJ: 16:21 - 16:29 2500' to 1000' to landing

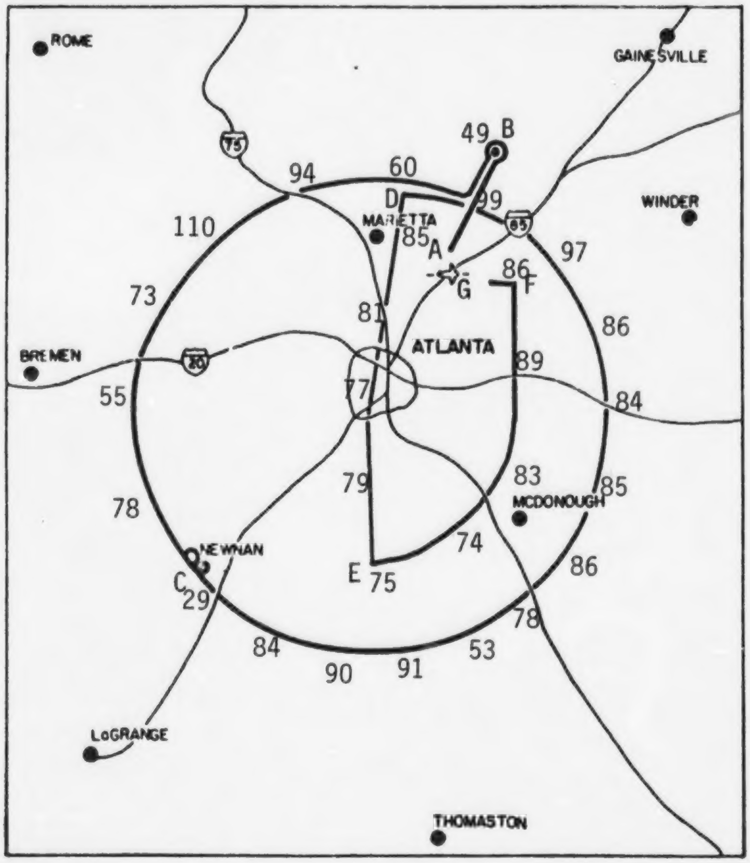


Figure E16. #81-16 on July 25, 1981

TIME: 8:37 to 10:50 AM

Leg AB: 8:37 - 8:47 up to 7000' AGL
BC: 8:47 - 9:29 7000' to 800' to 2500' tp 2000' tp 1500'
CD: 9:29 - 10:15 1500' to 1200' to 1500'
DE: 10:15 - 10:27 at 1500'
EF: 10:27 - 10:44 at 1500'
FG: 10:44 - 10:50 1500' to landing

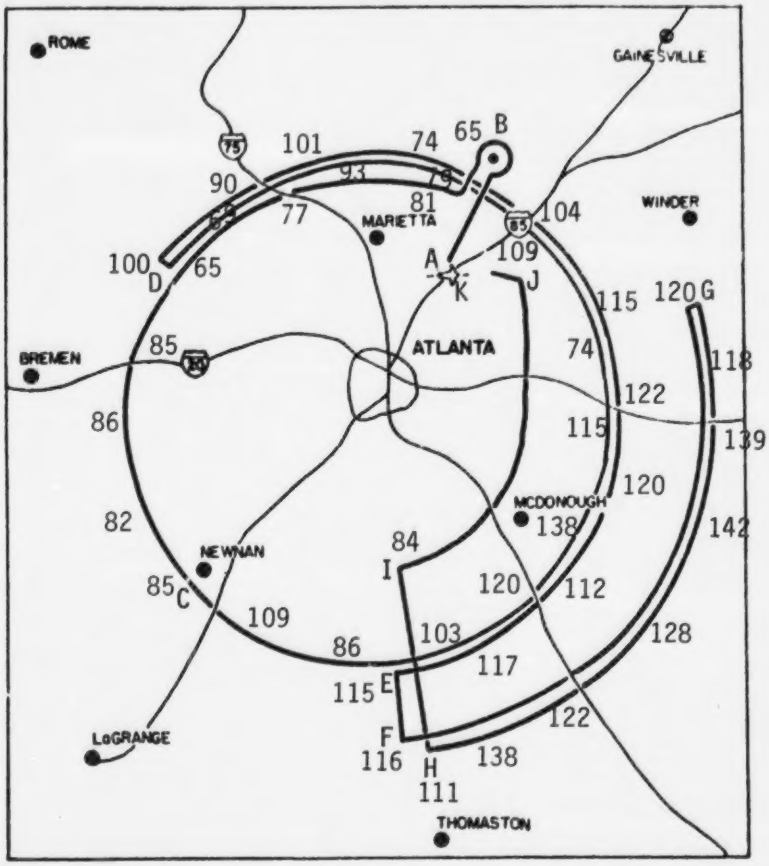


Figure E17. #81-17 on July 25, 1981

TIME: 12:37 to 16:23 PM

Leg AB: 12:37 - 12:47 up to 6000' to 5500' AGL
BC: 12:47 - 13:26 5500' to 1000' to 1500'
CD: 13:26 - 14:19 1500' to 2500'
DE: 14:19 - 14:59 at 2500'
EF: 14:59 - 15:03 at 2500'
FG: 15:03 - 15:29 2500' to 1500'
GH: 15:29 - 15:56 at 1500'
HI: 15:56 - 16:05 at 1500'
IJ: 16:05 - 16:18 at 1500'
JK: 16:18 - 16:23 1500' to landing

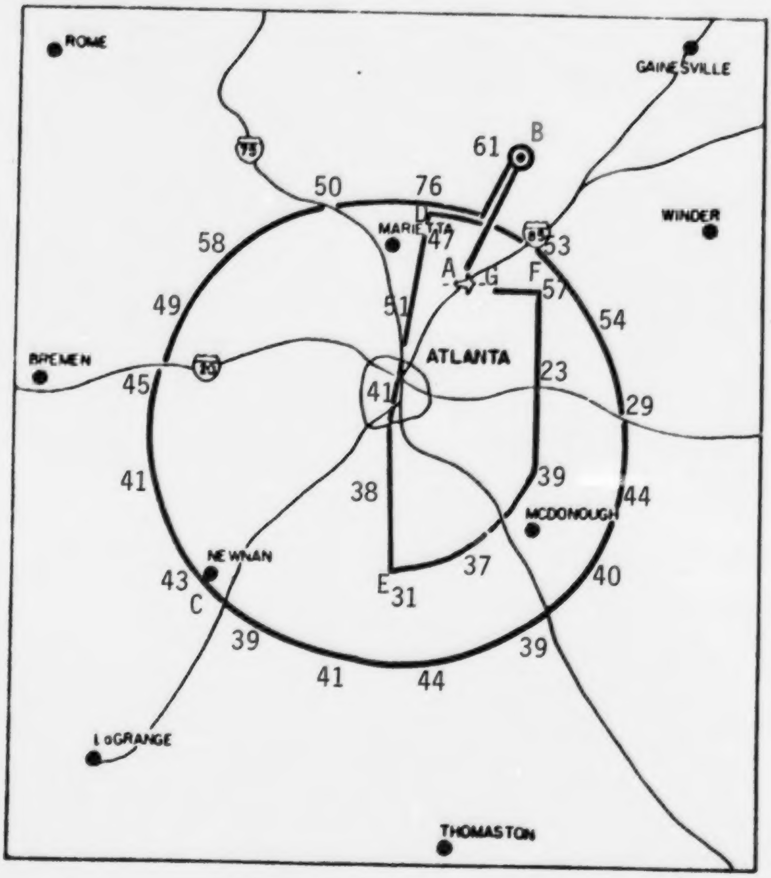


Figure E18. #81-18 on July 27, 1981

TIME: 8:48 to 10:59 AM

Leg AB: 8:48 - 8:59 up to 8000' AGL
BC: 8:59 - 9:37 8000' to 1500'
CD: 9:37 - 10:23 at 1500'
DE: 10:23 - 10:39 at 1500'
EF: 10:39 - 10:53 at 1500'
FG: 10:53 - 10:59 1500' to landing

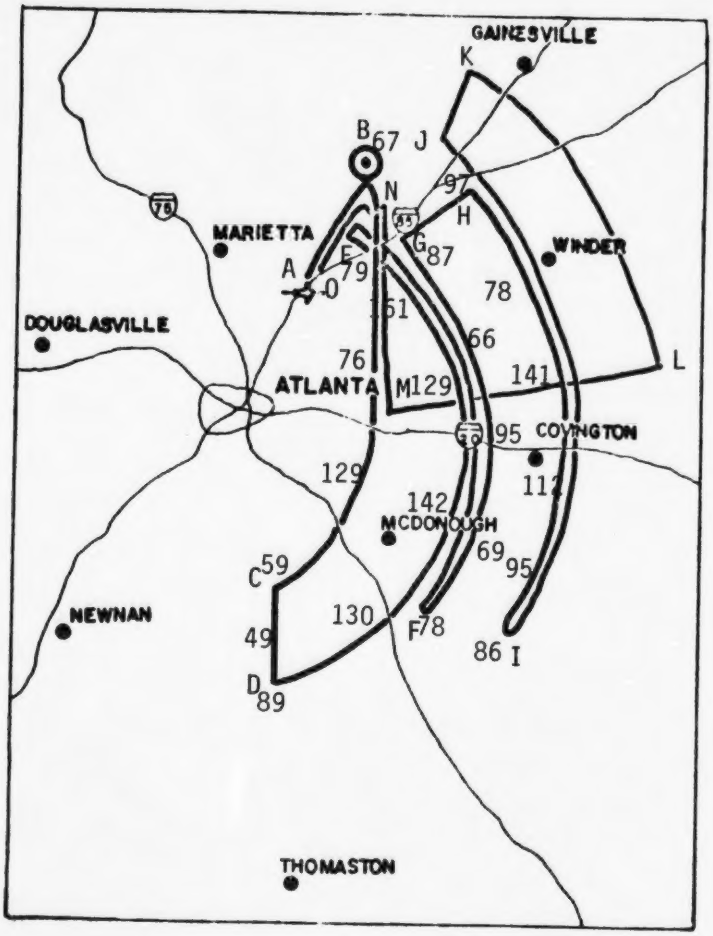


Figure E19. #81-19 on July 27, 1981

TIME: 13:36 to 17:32 PM

Leg AB: 13:36 - 13:47 up to 8000' AGL
BC: 13:47 - 14:28 8000' tp 1500'
CD: 14:28 - 14:31 at 1500'
DE: 14:31 - 14:56 1500' to 2500'
EF: 14:56 - 15:19 2500' to 3500'
FG: 15:19 - 15:36 3500' to 2500'
GH: 15:36 - 15:40 at 2500'
HI: 15:40 - 16:04 2500' to 1500'
IJ: 16:04 - 16:31 1500' to 2500'

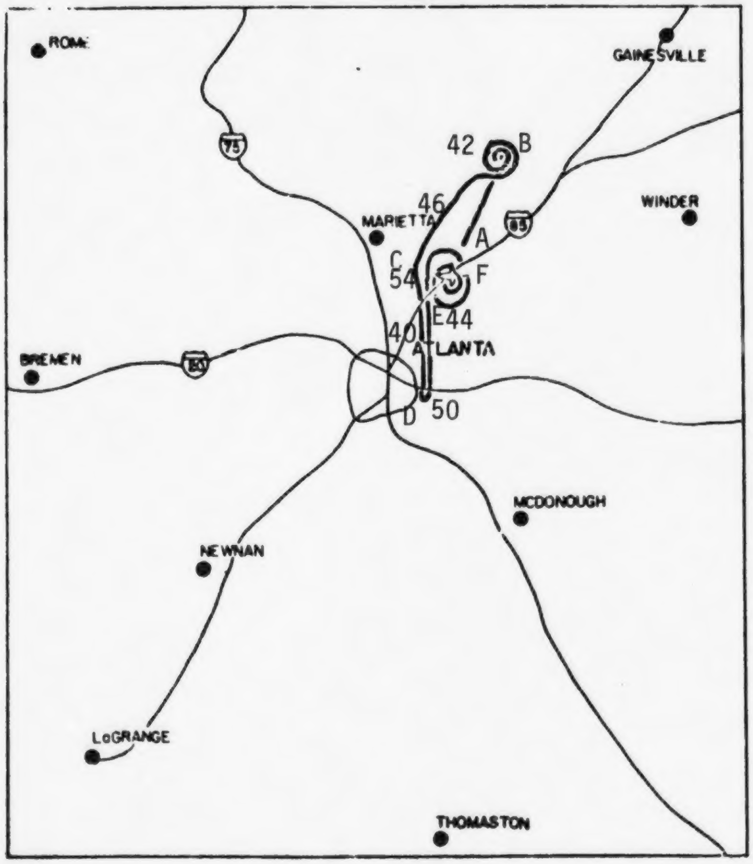


Figure E20. #81-20 on July 28, 1981

TIME: 7:38 to 8:36 AM

Leg AB: 7:38 - 7:44 up to 1500' AGL
BC: 7:44 - 7:56 1500' to 1800'
CD: 7:56 - 8:06 1800' to 4000'
DE: 8:06 - 8:14 4000' to 7500' to 7000'
EF: 8:14 - 8:36 7000' to 2000' to landing

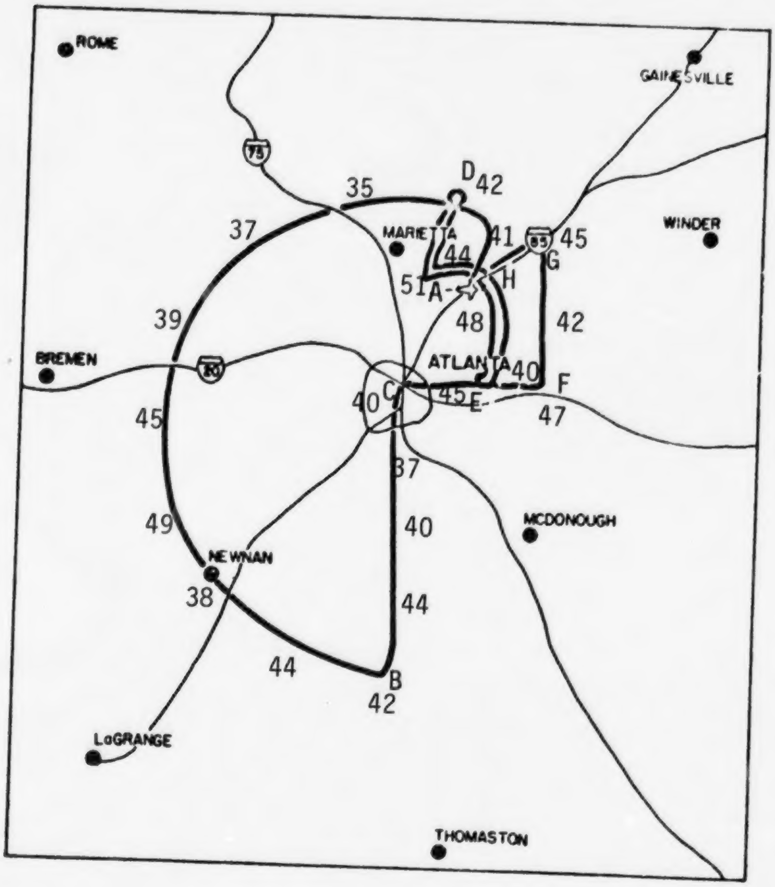


Figure E21. Flight #81-21 on July 28, 1981

TIME: 9:15 to 10:39 AM

Leg AB: 9:15 - 9:46 ascent to 1500' AGL
BC: 9:46 - 9:58 at 1500'
CD: 9:58 - 10:12 at 1500'
DE: 10:12 - 10:24 1500' to 2000' to 2500'
EF: 10:24 - 10:26 at 2500'
FG: 10:26 - 10:34 at 2500'
GH: 10:34 - 10:39 2500' to 200' to 100' to landing

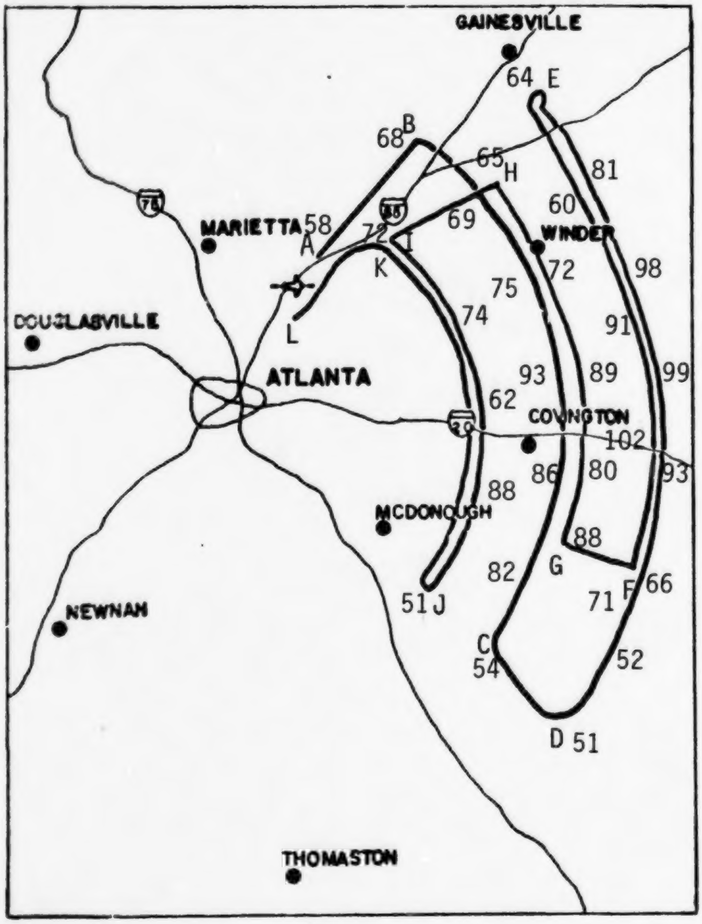


Figure E22. Flight #81-22 on July 28, 1981

TIME: 12:15 to 15:52 PM

Leg AB: 12:15 - 12:25 ascent to 1500' AGL
BC: 12:25 - 12:50 at 1500'
CD: 12:50 - 12:54 at 1500'
DE: 12:54 - 13:23 1500' to 2500'
EF: 13:23 - 13:46 at 2500'
FG: 13:46 - 13:48 at 2500'
GH: 13:48 - 14:09 at 2500'
HI: 14:09 - 14:13 at 2500'
IJ: 14:13 - 14:31 2500' to 1500'
JK: 14:31 - 14:47 at 1500'

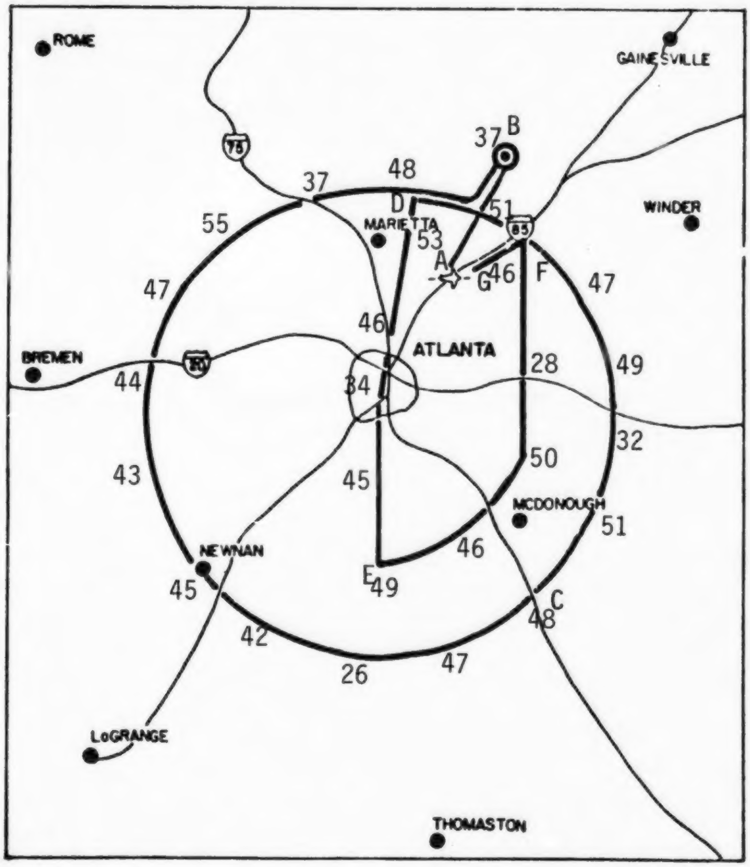


Figure E23. #81-23 on July 29, 1981

TIME: 8:22 to 10:41 AM

Leg AB: 8:22 - 8:50 up to 7500' to 1500' AGL
BC: 8:50 - 9:34 at 1500'
CD: 9:34 - 9:57 at 1500'
DE: 9:57 - 10:13 at 1500'
EF: 10:13 - 10:31 at 1500'
FG: 10:31 - 10:41 1500' to landing